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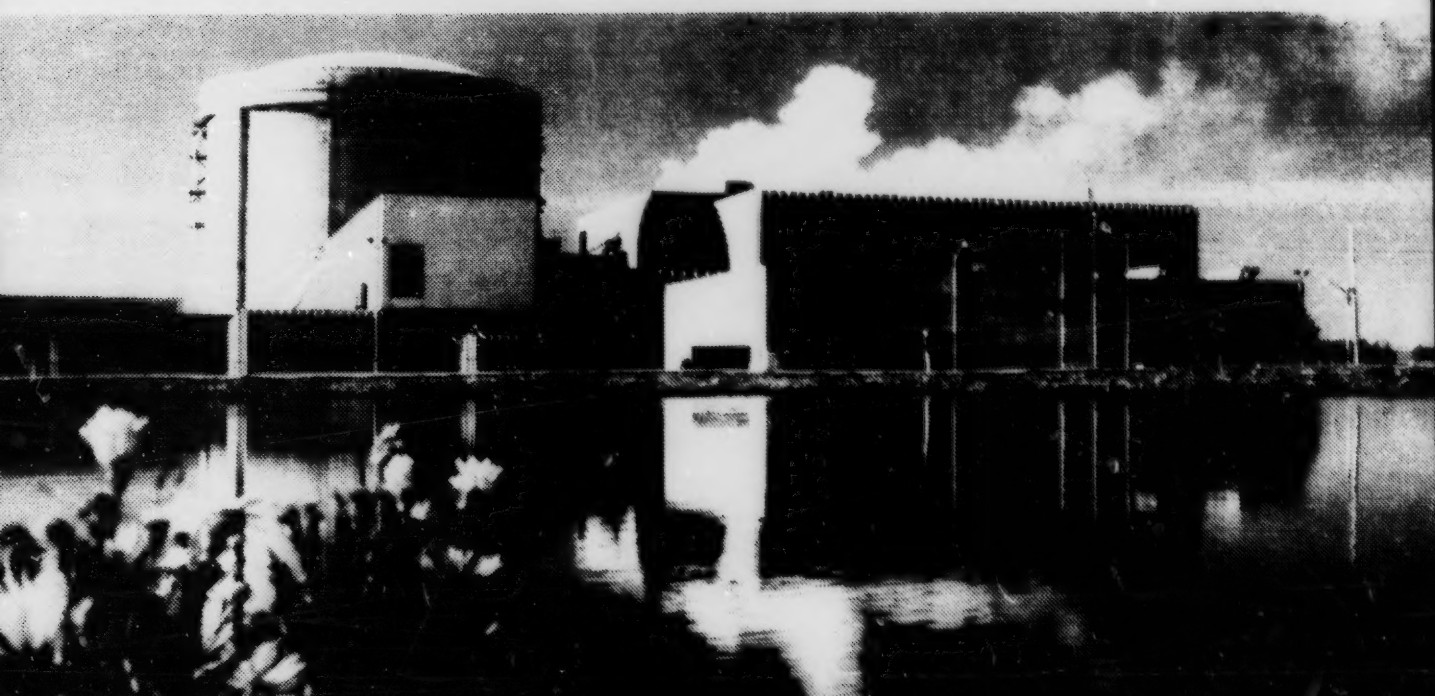

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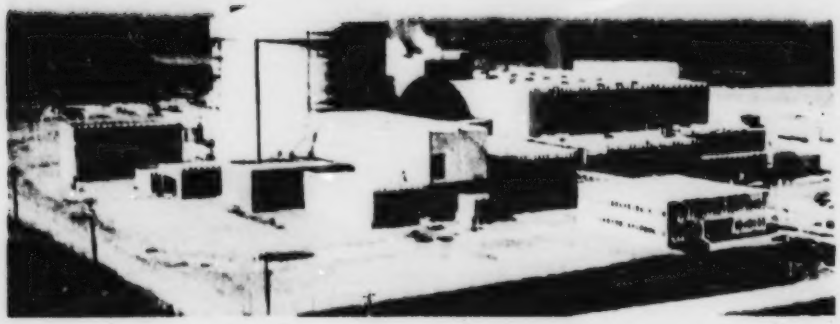
POINT LEPREAU GENERATING STATION

Environmental Radiation Monitoring Data

January 1, 2001 to December 31, 2001



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Executive Summary

This annual report is a compilation of the 2001 results from the Environmental Radiation Monitoring Program for the Point Lepreau Generating Station (PLGS).

Since 1976, the monitoring program has analysed more than 27 000 samples to define background radiation from natural and human sources. The contribution from human sources has declined significantly since atmospheric bomb tests have ceased. The program detected radionuclide fallout in New Brunswick after a Chinese atmospheric bomb test in 1980, and fallout from the accident at Chernobyl in 1986. There have been no regionally detectable releases of radiation from any human activity since these two events.

In 2001, there were 1881 analyses on 1353 samples to monitor environmental radiation around Point Lepreau and across the province in general. There were 701 analyses performed on 435 other samples, including 571 analyses of 363 Quality Assurance (QA) samples. The analyses indicate that radiation dose from PLGS emissions continues to be well below the public dose limit (1000 microsieverts per annum), and also well below the operating target for nuclear power facilities in Canada (50 microsieverts per annum).

The only assessable radiation dose from PLGS to the local population is that from tritiated water vapour in air. As in past years, tritium continues to be detected offsite in air and water samples. The only trend that was obvious from the historical data was increasing H-3 in Parshall Flume water from the Solid Radioactive Waste Management Facility (SRWMF) Phase 1. However, in 2001, this decreased to a ten year low.

Source of Dose to Critical Group	*Individual Dose (μSv/a)*
PLGS airborne emissions	0.39
PLGS liquid emissions	0.09
natural background (estimate)	2000

Groundwater received extra attention during 2001. Seven new monitoring wells were drilled near the SRWMF and 11 were drilled close to the plant. This more than doubled the number of onsite wells.

A complete program evaluation was conducted by the Canadian Nuclear Safety Commission (CNSC) in October 2001. Results were favourable and are included in this report.

The objectives of the program were met.

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1 Introduction

The licence to operate PLGS, issued by the Canadian Nuclear Safety Commission (CNSC), requires that NB Power maintain an Operational Environmental Radiation Monitoring Program (OERMP) during normal plant operations. This document describes the results of the program for the year 2001.

The requirement for this program is stated in *Radiation Protection Directives*[1] and *Solid Radioactive Waste Management Facility 1998 Safety Report*[2]. The underlying reason for this is the large inventory of radionuclides that exist on site. The program operates in conjunction with *Liquid and Gaseous Effluent Monitoring Program*[3], which monitors and controls effluents at their source. The Derived Emission Limits (DELs) are calculated in *Derived Emission Limits for Radionuclides in Airborne and Liquid Effluents*[4].

Monitoring of the site began in 1976 with the Pre-operational Program[5], which became the OERMP in 1982[6]. This was implemented when PLGS was declared "in-service" in February 1983. All radionuclide analyses in 2001 were performed in the Health Physics Environmental/Dosimetry Laboratory at 420 York Street, Fredericton, NB by the three full-time staff members (Health Physicist, Senior Technical Specialist and Technical Specialist).

The radiation monitoring program for PLGS is reviewed annually. This ensures that the samples collected, their frequency of collection, and the analytical techniques used are appropriate to achieve the objectives of the program. Late in 1999, the basis of the OERMP was extensively revised[7] to comply with *Guidelines for Radiological Monitoring of the Environment*[8], which did not exist when this program was first implemented.

The Environmental Radiation Monitoring Program for PLGS fulfils several objectives. These are to:

1) permit the estimation of dose to critical groups and populations from the radioactive emissions from PLGS and its Solid Radioactive Waste Management Facility (SRWMF). This is achieved through the analyses of environmental and effluent samples.

2) provide data to confirm compliance of PLGS and the SRWMF with release guidelines and regulations and to provide public assurance of compliance. This is achieved through the issuance of the annual report to all interested parties.

3) establish and maintain the capability for environmental monitoring so that an effective response can be made to emergency conditions. This is achieved by maintaining the resources to step up the monitoring program during increased emissions that are only likely during an accident. The ability to interpret the data and make recommendations is also maintained.

4) maintain a database to facilitate the detection of trends. This is achieved by storing all results on a computer system that has the capability of reporting and graphing any desired subsets of the data.

5) verify or refine environmental models used in the calculation of Derived Emission Limits (DELs). This is achieved by comparing the theoretical dispersion factor with one calculated empirically. As well, other exposure routes to the public are continually evaluated.

6) determine the fate of released radioactive materials to show whether any significant pathway to humans has been overlooked. This is achieved through the collection and analysis of sample media outside of the established program. As well, any results that are not consistent with effluent results are investigated.

The capability of the radiation monitoring laboratory is assessed through the QA program. Analytical checks are also conducted daily. Indicator radionuclides, for example K-40 in milk, seawater and other samples, show that the analyses are reproducible and that the operation of the laboratory has not changed significantly since it began.

The following sections will briefly describe the program. Details are provided on PLGS emissions, analyses results, trends, dose estimates, and the quality assurance program.

2 Point Lepreau Emission Data

Table 2.01 lists the production performance for PLGS since its beginning. Experience has shown that the years of lower capacity factors are usually the years with the lowest airborne emissions of most radionuclides, especially noble gases. The opposite is true for liquid emissions.

Table 2.01: PLGS Production Performance

Year	*Annual Gross Capacity Factor (%)*
1983	86
1984	90
1985	97
1986	94
1987	92
1988	96
1989	95
1990	96
1991	98
1992	87
1993	95
1994	94
1995	29
1996	83
1997	62
1998	68
1999	74
2000	71
2001	80
Lifetime (Since In-service)	84

Emissions from PLGS continue to be at low levels as indicated in Table 2.02. By the time these releases reach the edge of the exclusion zone, they are diluted below the detection limits of most analytical procedures. Laboratory staff monitor the results of the emissions programs so that adjustments can be made to sampling and analysis protocols. There were no unusual emissions during the year 2001.

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Table 2.01: PLGS Production Performance

Year	*Annual Gross Capacity Factor (%)*
1983	86
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Table 2.02: Radionuclides Detected in Effluents (2001)

Nuclide	*Gaseous Effluent DEL (Bq/a)*	*Release (Bq)*	*Liquid Effluent DEL (Bq/a)*	*Release (Bq)*
H-3	4.3E+17	1.3E+14	1.6E+19	1.5E+14
C-14	3.3E+15	2.2E+11	3.0E+14	2.8E+09
Na-24	5.6E+15		----------	
Ar-41	6.4E+16	4.0E+12	----------	
Sc-46	1.7E+14		----------	
Cr-51	2.4E+16		2.2E+15	6.6E+07
Mn-54	1.1E+14		6.4E+13	2.2E+06
Fe-55	----------		5.1E+14	
Fe-59	4.0E+14		3.1E+13	2.6E+07
Co-58	3.0E+14		7.5E+13	
Co-60	6.5E+12		1.8E+13	3.5E+08
Zn-65	7.1E+13		1.5E+13	
As-76	----------		3.2E+14	
Kr-85	1.9E+19		----------	
Kr-85m	5.2E+17	4.0E+10	----------	
Kr-87	9.4E+16	3.8E+09	----------	
Kr-88	2.8E+16	9.9E+10	----------	
Sr-89	3.7E+14		4.4E+16	
Sr-90	1.2E+13		2.2E+15	4.8E+05
Y-90	8.2E+15		4.0E+15	
Y-91	----------		3.1E+15	
Zr-95	1.7E+14		3.7E+13	1.8E+08
Nb-95	1.3E+14		1.1E+14	3.9E+08
Mo-99	5.4E+15		1.3E+16	
Ru-103	1.2E+15		1.8E+14	4.3E+05
Ru-106	7.7E+13		2.7E+14	
Ag-110m	3.8E+13		1.8E+13	7.7E+06
Sb-122	----------		1.8E+14	3.2E+06
Sb-124	2.5E+14		4.8E+13	2.5E+07
Sb-125	----------		1.9E+14	1.1E+06
Te-132	1.4E+15		2.9E+13	3.6E+05
I-123	----------		4.2E+16	

Table 2.02 (continued): Radionuclides Detected in Effluents

Nuclide	*Gaseous Effluent DEL (Bq/a)*	*Release (Bq)*	*Liquid Effluent DEL (Bq/a)*	*Release (Bq)*
I-125	----------		2.3E+14	
I-129	----------		1.9E+13	
I-131	2.2E+13		3.0E+14	
I-132	1.5E+16		2.4E+16	
I-133	8.9E+14		3.5E+15	
I-134	1.9E+16		3.6E+17	
I-135	7.7E+15		9.2E+15	
Xe-131m	9.9E+18		----------	
Xe-133	2.4E+18	3.8E+12	----------	
Xe-133m	2.8E+18		----------	
Xe-135	3.4E+17	1.2E+12	----------	
Xe-135m	2.0E+17	1.4E+10	----------	
Xe-138	2.2E+16	3.9E+10	----------	
Cs-134	1.9E+13		2.5E+14	
Cs-135	----------		3.4E+15	
Cs-136	----------		6.3E+14	
Cs-137	5.4E+12		4.0E+14	7.2E+06
Ba-140	7.4E+14		9.4E+15	
La-140	1.1E+16		4.7E+14	
Ce-141	2.1E+15		7.4E+14	6.4E+05
Ce-144	1.1E+14		2.8E+14	
Np-239	1.0E+16		----------	
Noble Gas	7.3E+16 (Bq-MeV)		----------	
Cu-64	----------		----------	
Sn-113	----------		----------	
Xe-137	----------	3.5E+10	----------	
Gd-153	----------		----------	1.9E+08
Tb-160	----------		----------	3.9E+07
Hf-181	----------		----------	
Alpha	----------		----------	1.1E+07
Beta	----------		----------	6.7E+07

Table 2.02: Radionuclides Detected in Effluents (2001)

Nuclide	*Gaseous Effluent DEL (Bq/a)*	*Release (Bq)*	*Liquid Effluent DEL (Bq/a)*	*Release (Bq)*
H-3	4.3E+17	1.3E+14	1.6E+19	1.5E+14
C-14	3.3E+15	2.2E+11	3.0E+14	2.8E+09
Na-24	5.6E+15		----------	
Ar-41	6.4E+16	4.0E+12	----------	
Sc-46	1.7E+14		----------	
Cr-51	2.4E+16		2.2E+15	6.6E+07
Mn-54	1.1E+14		6.4E+13	2.2E+06
Fe-55	----------		5.1E+14	
Fe-59	4.0E+14		3.1E+13	2.6E+07
Co-58	3.0E+14		7.5E+13	
Co-60	6.5E+12		1.8E+13	3.5E+08
Zn-65	7.1E+13		1.5E+13	
As-76	----------		3.2E+14	
Kr-85	1.9E+19		----------	
Kr-85m	5.2E+17	4.0E+10	----------	
Kr-87	9.4E+16	3.8E+09	----------	
Kr-88	2.8E+16	9.9E+10	----------	
Sr-89	3.7E+14		4.4E+16	
Sr-90	1.2E+13		2.2E+15	4.8E+05
Y-90	8.2E+15		4.0E+15	
Y-91	----------		3.1E+15	
Zr-95	1.7E+14		3.7E+13	1.8E+08
Nb-95	1.3E+14		1.1E+14	3.9E+08
Mo-99	5.4E+15		1.3E+16	
Ru-103	1.2E+15		1.8E+14	4.3E+05
Ru-106	7.7E+13		2.7E+14	
Ag-110m	3.8E+13		1.8E+13	7.7E+06
Sb-122	----------		1.8E+14	3.2E+06
Sb-124	2.5E+14		4.8E+13	2.5E+07
Sb-125	----------		1.9E+14	1.1E+06
Te-132	1.4E+15		2.9E+13	3.6E+05
I-123	----------		4.2E+16	

Table 2.02 (continued): Radionuclides Detected in Effluents

Nuclide	*Gaseous Effluent DEL (Bq/a)*	*Release (Bq)*	*Liquid Effluent DEL (Bq/a)*	*Release (Bq)*
I-125	----------		2.3E+14	
I-129	----------		1.9E+13	
I-131	2.2E+13		3.0E+14	
I-132	1.5E+16		2.4E+16	
I-133	8.9E+14		3.5E+15	
I-134	1.9E+16		3.6E+17	
I-135	7.7E+15		9.2E+15	
Xe-131m	9.9E+18		----------	
Xe-133	2.4E+18	3.8E+12	----------	
Xe-133m	2.8E+18		----------	
Xe-135	3.4E+17	1.2E+12	----------	
Xe-135m	2.0E+17	1.4E+10	----------	
Xe-138	2.2E+16	3.9E+10	----------	
Cs-134	1.9E+13		2.5E+14	
Cs-135	----------		3.4E+15	
Cs-136	----------		6.3E+14	
Cs-137	5.4E+12		4.0E+14	7.2E+06
Ba-140	7.4E+14		9.4E+15	
La-140	1.1E+16		4.7E+14	
Ce-141	2.1E+15		7.4E+14	6.4E+05
Ce-144	1.1E+14		2.8E+14	
Np-239	1.0E+16		----------	
Noble Gas	7.3E+16 (Bq-MeV)		----------	
Cu-64	----------		----------	
Sn-113	----------		----------	
Xe-137	----------	3.5E+10	----------	
Gd-153	----------		----------	1.9E+08
Tb-160	----------		----------	3.9E+07
Hf-181	----------		----------	
Alpha	----------		----------	1.1E+07
Beta	----------		----------	6.7E+07

3 Sample Media, Locations and Frequencies

The data contained in this report are for samples collected from January 1 to December 31, 2001, with some overlap for air, precipitation and thermoluminescent dosimeter (TLD) samples. During this time, the major media analysed and their frequency of collection were as indicated in Table 3.01. Sample collection usually takes place at least once each week throughout the year. The number of each sample type and the major radionuclide measurements performed are listed in Table 3.02.

The miscellaneous samples include those, which do not readily fit into any of these listed categories or are not routinely collected. These include numerous in-station samples (e.g. drinking water) relating to the operation of PLGS.

The major sample locations are listed in Table 3.03 (details in Appendix C) and shown in Figures 3.02 to 3.05. Each "Indicator" site has a three or four-character identification code (e.g. F01, I10A). An Indicator site is one within the possible influence of PLGS emissions. "Reference" locations, chosen to lie outside the influence of PLGS emissions, are identified by the letter R at the end of the location code (e.g. A01R).

Sample locations for mobile seafood species (lobster, fish, etc.) caught in the Point Lepreau area are specified as accurately as reasonably possible. The location of capture, however, may bear little relationship to where the animal has been in the recent past. The availability of such samples is not generally predictable and is outside of the control of the laboratory.

Table 3.01: Schedule of Sample Collection and Analysis

Sample Medium	*Typical Frequency*
Atmospheric Sampling	
Airborne Particulates	Monthly (integrated sample)
Airborne Iodines	Monthly (integrated sample)
Airborne Water Vapour	Monthly (integrated sample)
Airborne Carbon Dioxide	Monthly (integrated sample)
Ambient Gamma (TLDs)	Quarterly (integrated sample)
Gaseous Effluent Monitor (GEM) Filters	Weekly Composite (integrated sample)
Terrestrial Sampling	
Ambient Gamma (TLDs)	Quarterly (integrated sample)
Milk - commercial dairy - dairy farms	Monthly Quarterly
Well Water	Semi-annually
Pond, Puddle and Surface Water	Quarterly
Berries	As Available
Garden Vegetables	As Available
Vegetation	Quarterly
Soil	Quarterly
Bore Holes	Quarterly
Precipitation	Monthly (integrated sample)
Marine Sampling	
Seawater	Quarterly
Clams	As Available
Fish	As Available
Lobster	As Available
Periwinkles	As Available
Aquaculture Salmon	As Available
Scallops	As Available
Crabs	As Available
Dulse	As Available
Other Sea Plants	Quarterly
Sediment	Quarterly
Gamma Surveys (Beaches)	Quarterly
Liquid Effluent Monitor (LEM) Composite	Monthly Composite (integrated sample)

Table 3.01 (continued): Schedule of Sample Collection and Analysis

Sample Medium	*Typical Frequency*
Solid Radioactive Waste Management Facility	
Bore Holes	Quarterly
Parshall Flumes	Weekly
Ambient Gamma (TLDs)	Quarterly (integrated sample)
Hemlock Knoll Regional Sanitary Landfill	
Bore Holes	Semi-annually
Water (leachate and settling/holding ponds)	Monthly to Semi-annually
Ambient Gamma (TLDs)	Quarterly (integrated sample)

Table 3.02: Sample Information

Sample Medium	*Number of Samples*	*Radionuclide Measurements*
	Atmospheric Sampling	
Airborne Particulates	96	gamma emitters & gross alpha/beta
Airborne Iodines	96	I-130,131,132,133,135
Airborne Water Vapour	96	H-3
Airborne Carbon Dioxide	35	C-14
Ambient Gamma (TLDs)*	154*	gamma exposure
GEM Filters	53	Sr-89,90 & gamma emitters
	Terrestrial Sampling	
Ambient Gamma (TLDs)*	154*	gamma exposure
Milk - commercial dairy - dairy farms	12 12	gamma emitters & H-3
Well Water	34	gamma emitters, gross alpha/beta & H-3
Pond, Puddle and Surface Water	18	gamma emitters & H-3
Berries	5	gamma emitters
Garden Vegetables	17	gamma emitters
Vegetation	16	gamma emitters
Soil	36	gamma emitters
Near Plant Monitoring Wells	10	gamma emitters & H-3
Precipitation	40	gamma emitters & H-3
	Marine Sampling	
Seawater	16	gamma emitters & H-3
Clams	12	gamma emitters
Fish	1	gamma emitters
Lobster	8	gamma emitters
Periwinkles	11	gamma emitters
Aquaculture Salmon	5	gamma emitters
Scallops	3	gamma emitters
Crabs	1	gamma emitters
Dulse	9	gamma emitters
Other Sea Plants	12	gamma emitters
Sediment	40	gamma emitters
Gamma Surveys (Beaches)	40	gamma exposure
LEM Composite	12	Sr-89,90, gamma emitters, gross alpha/beta

*One TLD measures the gamma dose from radionuclides in the air and on the ground.

Table 3.02 (continued): Sample Information

Sample Medium	*Number of Samples*	*Radionuclide Measurements*
Solid Radioactive Waste Management Facility		
Bore Holes	46	gamma emitters & H-3
Parshall Flumes	104	gamma emitters & H-3
Ambient Gamma (TLDs)	167	gamma exposure
Hemlock Knoll Regional Sanitary Landfill		
Solid	10	gamma emitters
Bore Holes	75	gamma emitters & H-3
Liquid (leachate and settling/holding ponds)	20	gamma emitters & H-3
Gamma Surveys	10	gamma exposure
Ambient Gamma (TLDs)	20	gamma exposure
Other		
Miscellaneous	72	as required
Quality Assurance	363	as required

Table 3.03: General Location Codes

Code	*Location*
A	West of Pennfield Ridge
B	Pennfield to New River Beach (inclusive)
C	Lepreau and Lepreau Harbour
D	Little Lepreau and Little Lepreau Basin
E	Maces Bay
F	Welch Cove
G	Pt. Lepreau lighthouse and surrounding area
H	Duck Cove
I	PLGS site – northeast quadrant
J	PLGS site – southeast quadrant
K	PLGS site – southwest quadrant
L	PLGS site – northwest quadrant
M	PLGS
N	Dipper Harbour
P	East of Dipper Harbour East to Musquash
Q	Lorneville
S	Saint John and surrounding area
T	Taymouth
X	Fredericton and surrounding area
Y	Hemlock Knoll Regional Sanitary Landfill

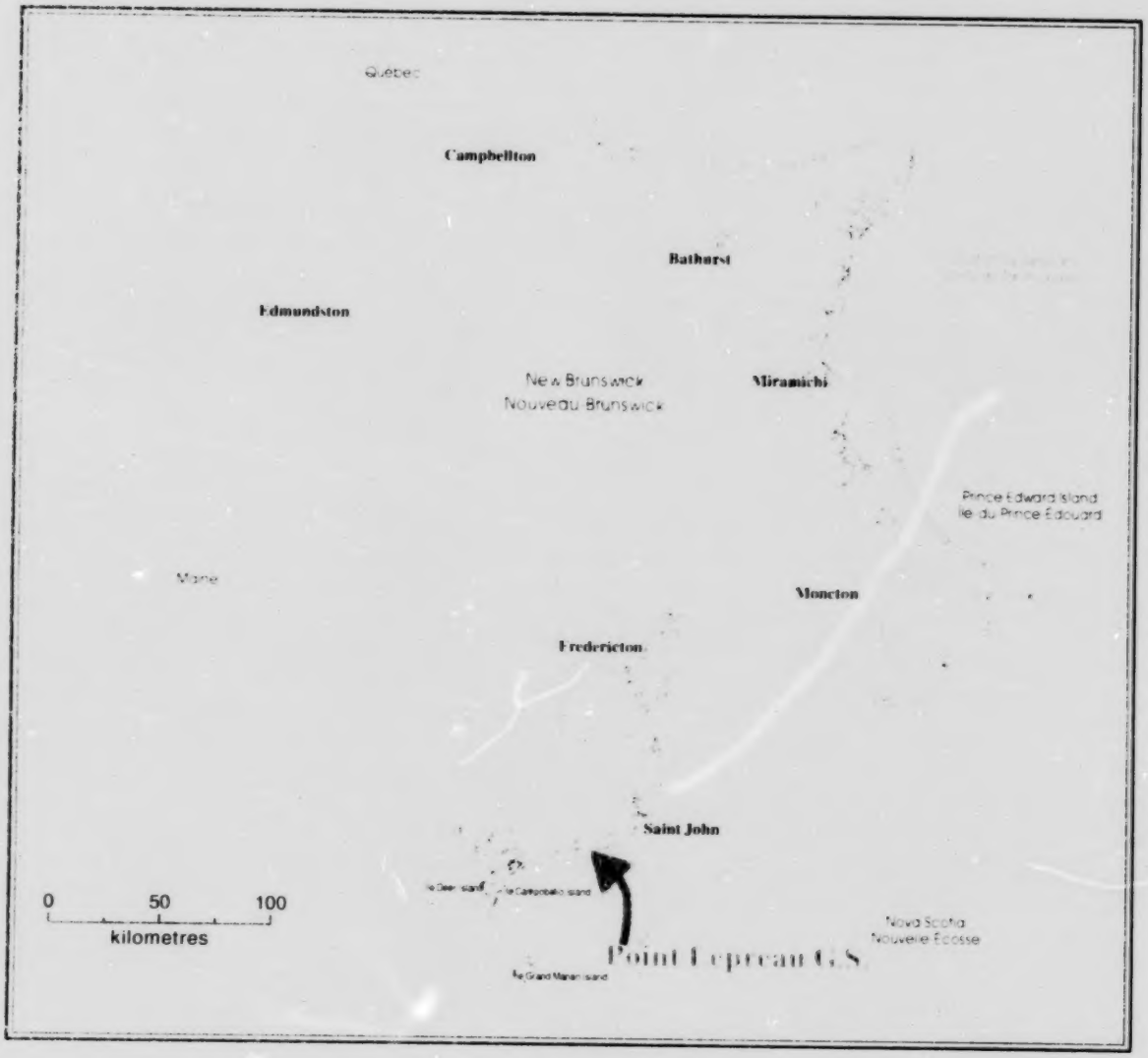

Figure 3.01: Map of Region

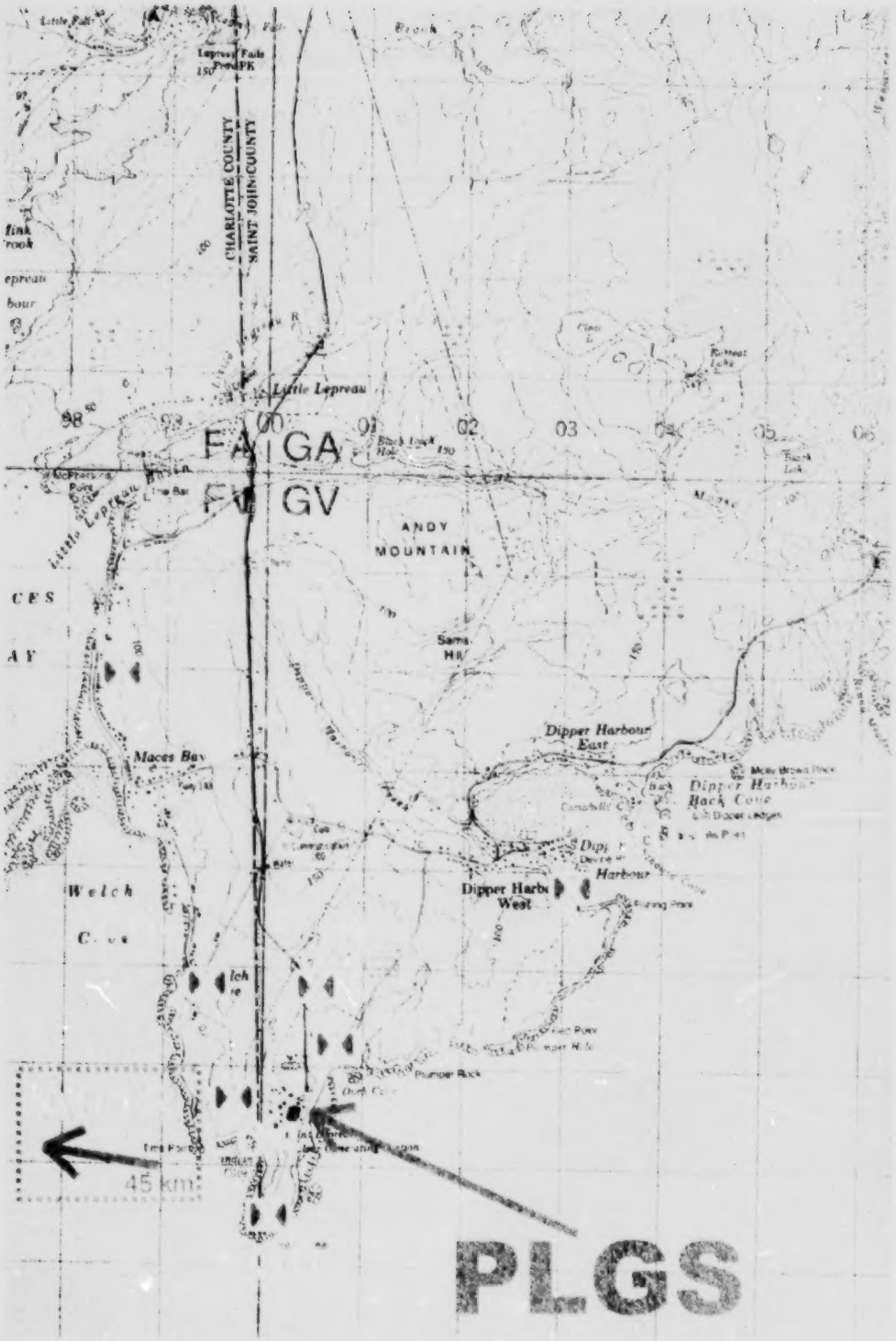

Figure 3.02: Air Monitoring Stations

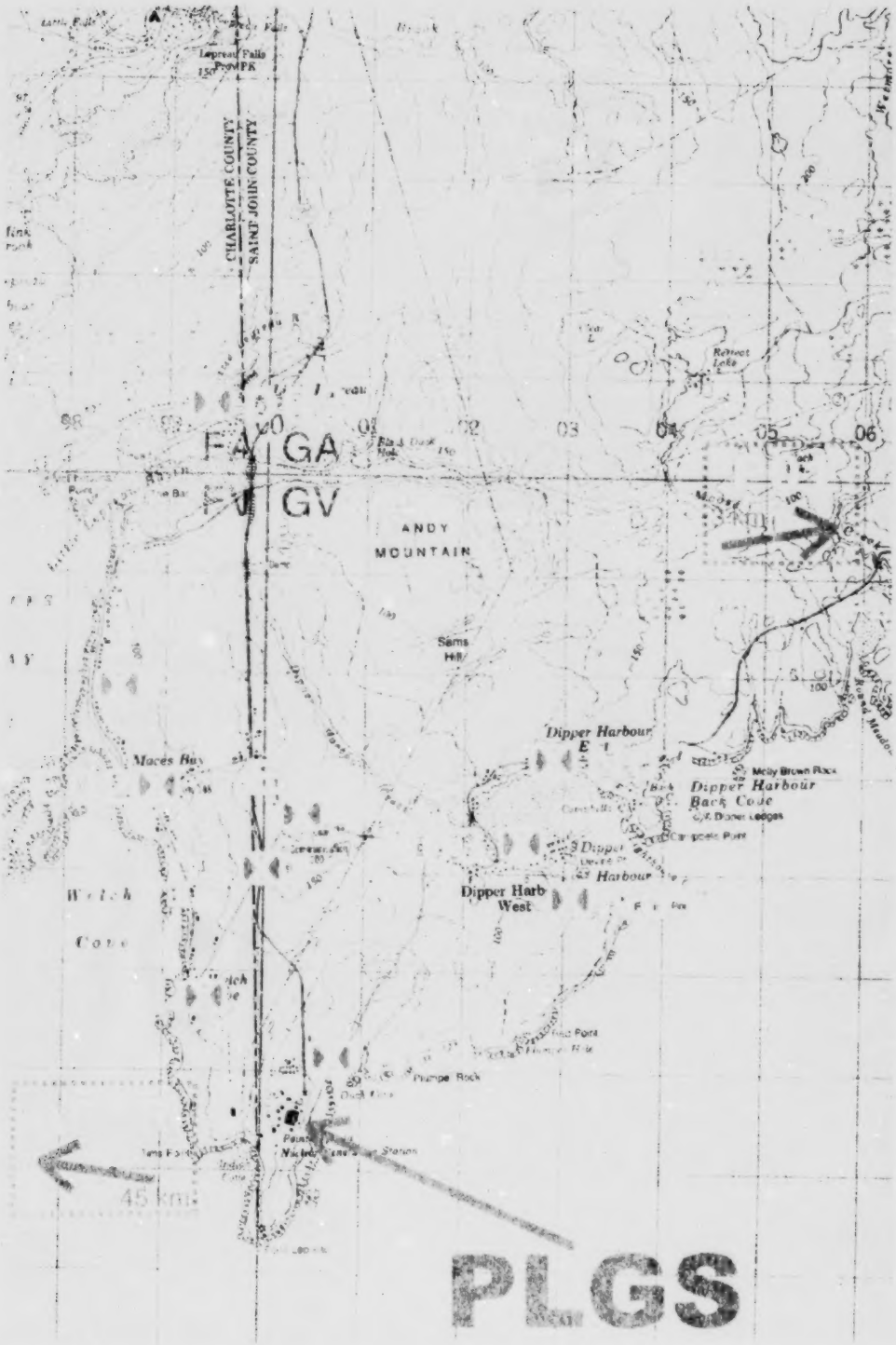

Figure 3.03: Well Water Sites

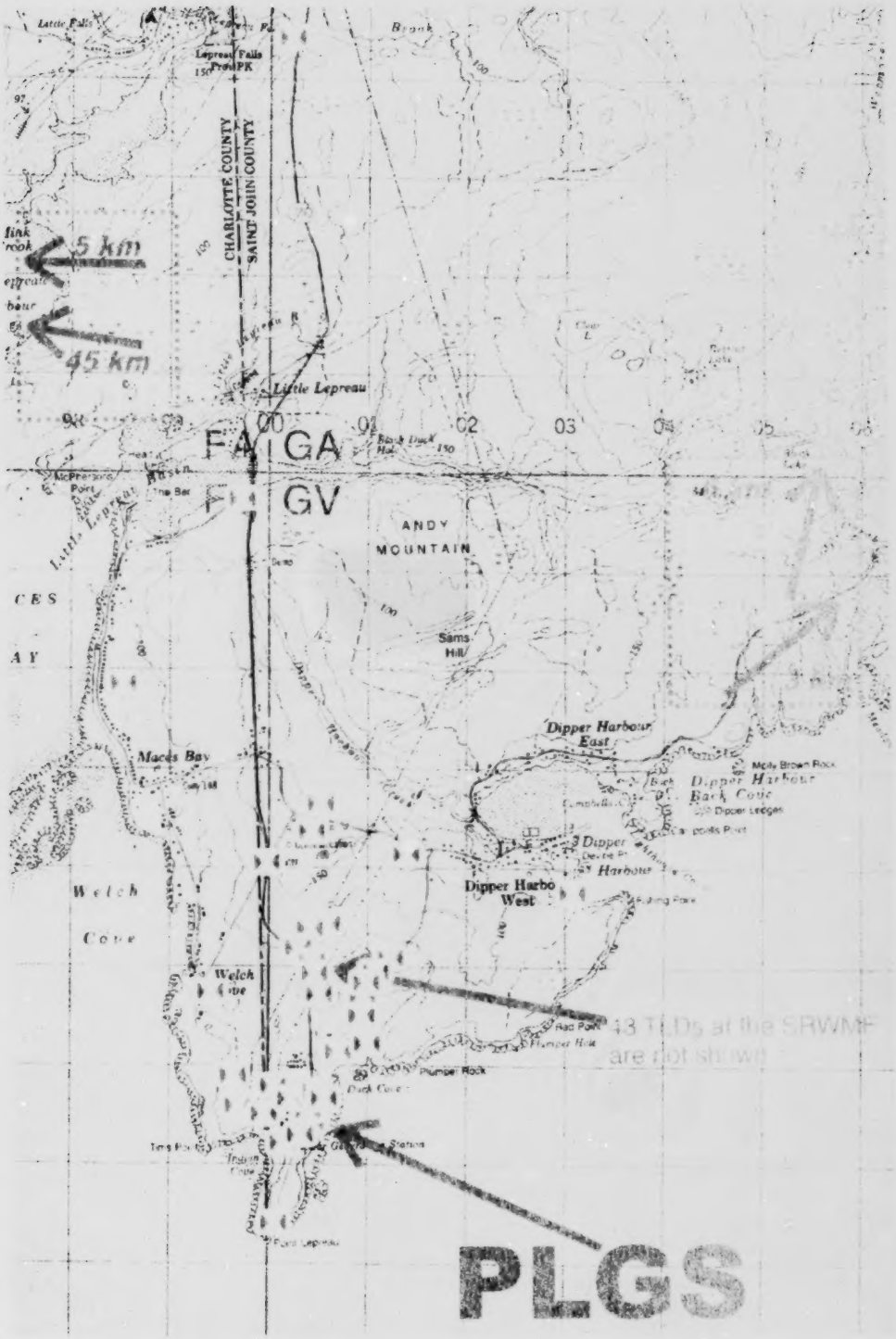

Figure 3.04: TLD Sites

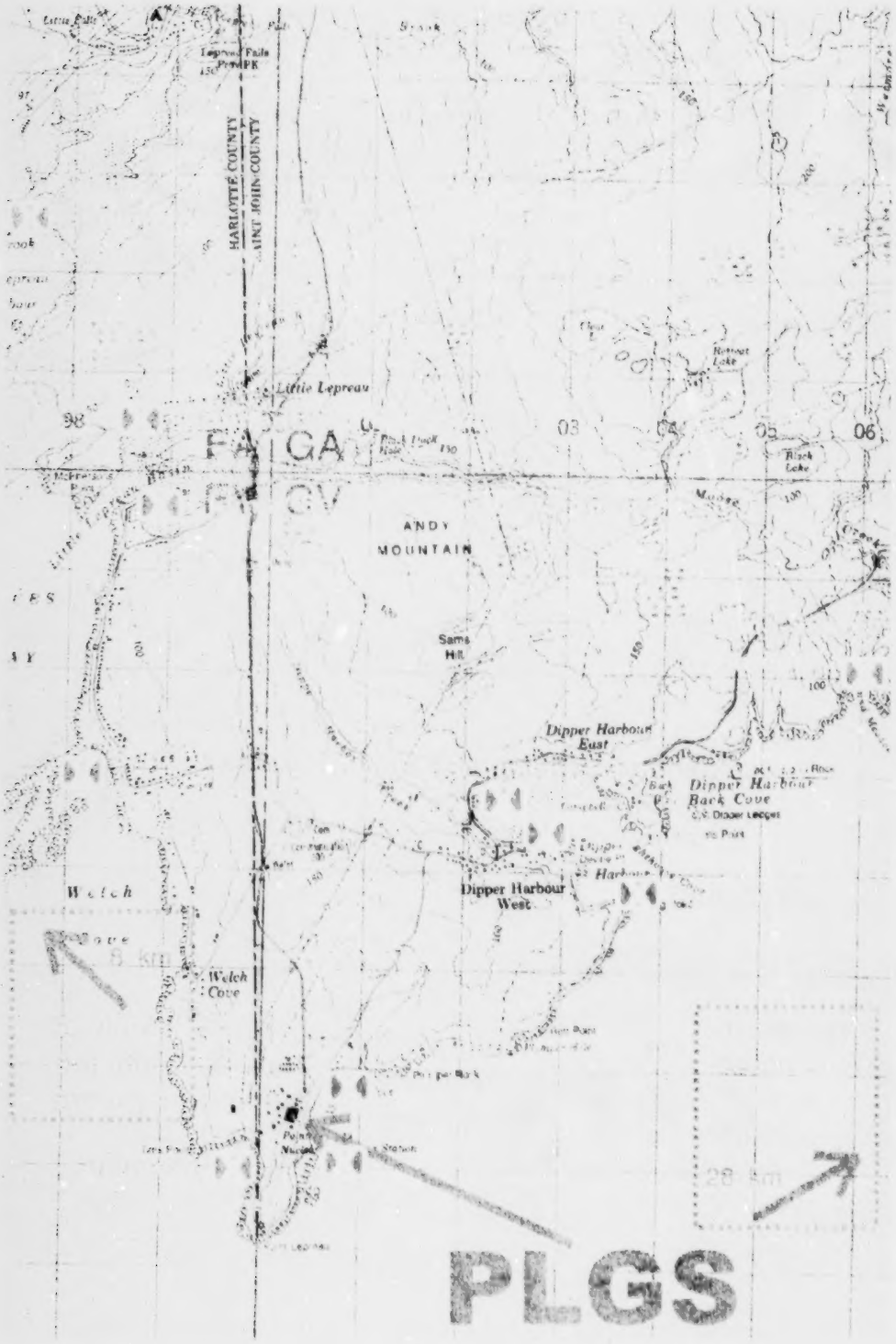

Figure 3.05: Marine Monitoring Sites

4 Summary and Discussion of Data

The following is a summary and discussion of the data on environmental samples collected for the year 2001.

Most samples contained detectable levels of naturally occurring (K-40) or cosmogenic (Be-7) radionuclides. Some contained Cs-137 (soils, sediments, lichen) from the atmospheric bomb tests of past years and the Chernobyl accident. The only radionuclide originating from PLGS that is detected consistently is tritium (in air and fresh water). In 2001, analyses that indicated emissions traceable to PLGS were:

- H-3 in airborne water vapour and fresh water
- gross beta in air at onsite locations
- TLD measurements at onsite locations
- H-3 in Parshall flume and bore hole water from the Solid Radioactive Waste Management Facility (SRWMF)

The only assessable radiation dose from PLGS on the local population is that from tritiated water vapour in air. Offsite, the activity of H-3 in air ranges from less than about 2E-2 Bq/m^3 (below the lower limit of detection by the method used) to about 0.6 Bq/m^3 of air. The natural concentration of H-3 is up to 0.7 Bq/L in most surface waters and up to 1E-3 Bq/m^3 in air.

The natural concentration of C-14 in the atmosphere is approximately 4E-2 Bq/m^3. This level is usually detected by the sensitive analytical method used in the monitoring program.

Only detected radionuclides are listed in the following tables. Refer to Tables A.01 to A.11 in Appendix A for detailed listings of detection limits. Most tables contain the following data:

Column 1 - Shows the type of analysis or nuclide.

Column 2 - Shows the total number of samples analysed.

Column 3 – Shows the mean of the Critical Levels (CLs) for all samples. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 4 - Shows the range of the Critical Levels (CLs) for all samples. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 5 - Shows the mean of the detected values (i.e., values exceeding the CL) for all Indicator stations.

Column 6 - Shows the ratio of the number of detected values to the total number of Indicator samples.

Column 7 - Shows the range of detected values for the Indicator stations.

Column 8 - Shows the mean of detected values at the Reference location(s).

Column 9 - Shows the ratio of detected values to the total number of samples at this location.

Column 10 - Shows the range of detected values for the Reference location(s).

4.01 Airborne Particulates

In 2001, there were no detectable airborne particulate radionuclides that could be attributed to the operation of PLGS on any of the 96 samples analysed. However, the gross beta values were slightly higher at onsite locations than offsite locations.

Air is continuously monitored from the eight locations shown in Figure 3.02. Once a month the filters are changed and analysed. There were only 21 collection days lost (total for two locations) in 2001. It is not uncommon to lose some monitoring time due to mechanical or electrical problems.

Gross alpha and gross beta measurements are an indication of total activity in the environment. This includes naturally occurring radon progeny, cosmogenic (Be-7), and man-made sources of radiation. Table 4.01 is a summary of detected radionuclides. Figures 4.01 and 4.02 show the gross beta results for each location throughout the year. There is a slight seasonal trend as well as a small difference between onsite and offsite results.

Table 4.01: Airborne Particulates (Bq/m^3)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Alpha	96	3.3E-6	1.2E-6 to 1.0E-5	2.5E-5	84/84	5.1E-6 to 1.2E-4	2.2E-5	12/12	9.2E-6 to 4.3E-5
Beta	96	6.3E-6	2.4E-6 to 2.0E-5	3.0E-4	84/84	8.9E-5 to 1.6E-3	2.9E-4	12/12	1.3E-4 to 5.0E-4
Be-7	96	3.4E-4	3.9E-5 to 1.9E-3	1.2E-3	83/84	3.3E-4 to 7.1E-3	8.2E-4	12/12	4.0E-4 to 1.6E-3

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.01: Airborne Particulates (Bq/m^3)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Alpha	96	3.3E-6	1.2E-6 to 1.0E-5	2.5E-5	84/84	5.1E-6 to 1.2E-4	2.2E-5	12/12	9.2E-6 to 4.3E-5
Beta	96	6.3E-6	2.4E-6 to 2.0E-5	3.0E-4	84/84	8.9E-5 to 1.6E-3	2.9E-4	12/12	1.3E-4 to 5.0E-4
Be-7	96	3.4E-4	3.9E-5 to 1.9E-3	1.2E-3	83/84	3.3E-4 to 7.1E-3	8.2E-4	12/12	4.0E-4 to 1.6E-3

*The activity is less than or equal to the Critical Level (99% Confidence Level).

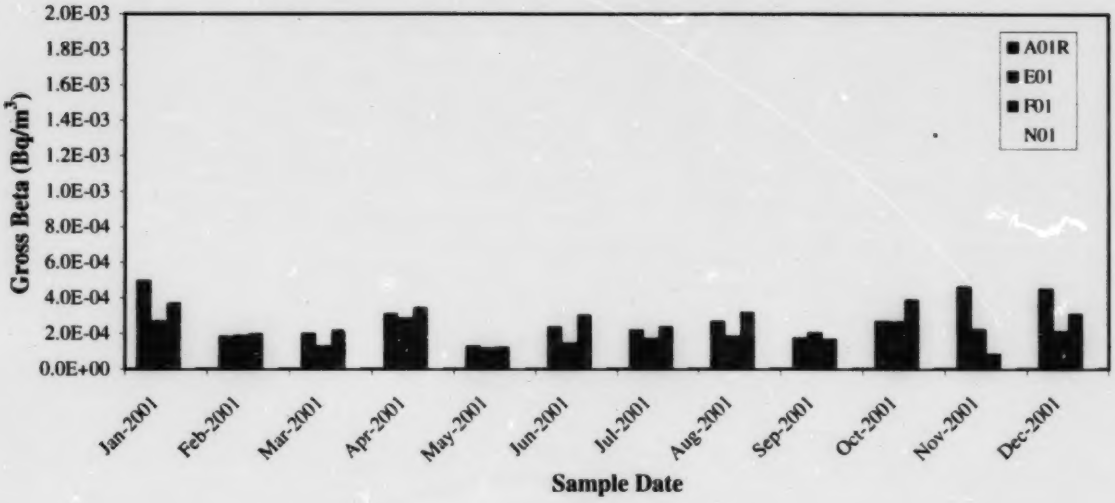

Figure 4.01: Gross Beta in Air for Each Offsite Air Station

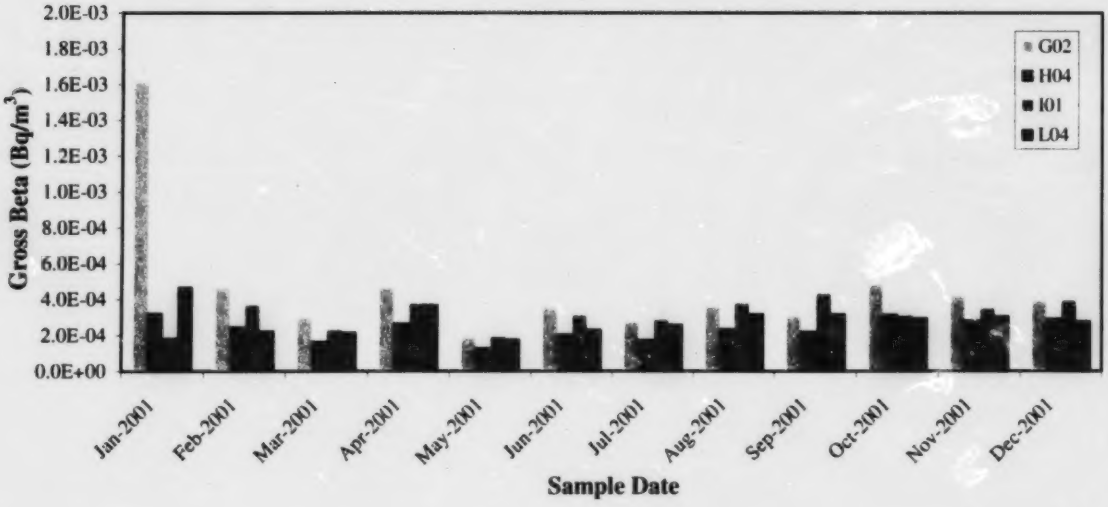

Figure 4.02: Gross Beta in Air for Each Onsite Air Station

4.02 Airborne Iodines

Iodine-131 was consistently below the Critical Level (average 7E-6 Bq/m^3) on the 96 samples analysed.

Air is monitored continuously from the eight locations shown in Figure 3.02. Once a month the cartridges are changed and analysed. There were only 21 collection days lost (total for two locations) in 2001. It is not uncommon to lose some monitoring time due to mechanical or electrical problems.

The results are consistent with the fact that I-131 was not detected in the emissions from PLGS.

4.03 Water Vapour

Tritium was detected in 72 of the 84 samples collected from the air monitoring stations on the Point Lepreau peninsula in 2001, and was not detected in the 12 samples at the reference location.

Air is monitored continuously from the eight locations shown in Figure 3.02. Once a month the molecular sieve bombs are changed and analysed. There were only 21 collection days lost (total for two locations) in 2001. It is not uncommon to lose some monitoring time due to mechanical or electrical problems.

The maximum concentration of tritium in air on site was 7.7 Bq/m^3 of air. Off site it reached 0.6 Bq/m^3. Tritium has been detected from time to time at the reference location, even before PLGS became operational.

Table 4.02 is the summary table of 2001 tritium data and Table 4.03 gives details of 2001 tritium results by location (graphically shown in Figures 4.03 and 4.04). Locations to the northeast (H04, I01 and N01) have elevated H-3 measurements in the warmer months due to the predominant summer wind direction that changes in the winter to impact the southwest locations (G02 and L04).

Table 4.02: Water Vapour - Tritium (Bq/m^3)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	96	6.1E-2	1.7E-2 to 1.3E-1	8.4E-1	72/84	3.1E-2-7.7E+0	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.03: Water Vapour - Tritium (Bq/m^3)

Location Code		A01R	E01	F01	G02	H04	I01	L04	N01
Location		Bocabec	Maces Bay	Welch Cove	Lepreau Lighthouse	Old Site of Information Centre	SRWMF	Construction Stores	Dipper Harbour
Distance from PLGS		45 km	4.5 km	1.6 km	1.0 km	0.75 km	1.2 km	0.55 km	3.7 km
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	2001-01-03	<3.6E-2	4.2E-2	6.9E-2	8.5E-1	4.4E-1	1.0E+0	7.3E-1	3.1E-2
	2001-02-07	<2.0E-2	<4.0E-2	1.3E-1	9.2E-1	1.3E+0	6.8E-1	9.2E-1	6.2E-2
	2001-03-14	<4.5E-2	<4.2E-2	<5.3E-2	7.6E-1	4.6E-1	7.9E-1	3.9E-1	1.9E-1
	2001-04-11	<3.7E-2	<4.0E-2	6.4E-2	4.6E-1	1.4E+0	1.6E+0	1.0E+1	3.8E-1
	2001-05-09	<9.0E-2	1.8E-1	1.3E-1	5.5E-1	7.7E+0	1.3E+0	7.3E-1	2.2E-1
	2001-06-07	<6.7E-2	4.7E-1	1.8E-1	1.5E-1	2.4E+0	1.2 E+0	6.0E-1	5.5E-1
	2001-07-04	<5.6E-2	1.0E-1	3.9E-1	1.0E+0	1.9E+0	1.6E+0	2.5E-1	3.7E-1
	2001-08-01	<9.8E-2	<1.3E-1	1.2E-1	<1.9E-1	1.3E+0	2.7E+0	2.7E-1	4.3E-1
	2001-09-05	<7.2E-2	<1.4E-1	2.5E-1	3.3E-1	1.4E+0	2.3E+0	1.1E+0	4.3E-1
	2001-10-03	<3.8E-2	<7.9E-2	<8.0E-2	<9.5E-2	1.8E+0	1.8E+0	3.6E-1	3.7E-1
	2001-10-31	<6.2E-2	8.3E-2	<8.3 E-2	3.8E-1	1.9E+0	3.1 E+0	2.2E-1	1.8E-1
	2000-11-27	<3.5E-2	<3.3E-2	2.0E-1	5.9E-1	8.3E-1	1.1E+0	4.9E-1	9.1E-2

Table 4.03: Water Vapour - Tritium (Bq/m^3)

Location Code		*A01R*	*E01*	*F01*	*G02*	*H04*	*I01*	*L04*	*N01*
Location		*Bocabec*	*Maces Bay*	*Welch Cove*	*Lepreau Lighthouse*	*Old Site of Information Centre*	*SRWMF*	*Construction Stores*	*Dipper Harbour*
Distance from PLGS		*45 km*	*4.5 km*	*1.6 km*	*1.0 km*	*0.75 km*	*1.2 km*	*0.55 km*	*3.7 km*
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	2001-01-03	<3.6E-2	4.2E-2	6.9E-2	8.5E-1	4.4E-1	1.0E+0	7.3E-1	3.1E-2
	2001-02-07	<2.0E-2	<4.0E-2	1.3E-1	9.2E-1	1.3E+0	6.8E-1	9.2E-1	6.2E-2
	2001-03-14	<4.5E-2	<4.2E-2	<5.3E-2	7.6E-1	4.6E-1	7.9E-1	3.9E-1	1.9E-1
	2001-04-11	<3.7E-2	<4.0E-2	6.4E-2	4.6E-1	1.4E+0	1.6E+0	1.0E+1	3.8E-1
	2001-05-09	<9.0E-2	1.8E-1	1.3E-1	5.5E-1	7.7E+0	1.3E+0	7.3E-1	2.2E-1
	2001-06-07	<6.7E-2	4.7E-1	1.8E-1	1.5E-1	2.4E+0	1.2 E+0	6.0E-1	5.5E-1
	2001-07-04	<5.6E-2	1.0E-1	3.9E-1	1.0E+0	1.9E+0	1.6E+0	2.5E-1	3.7E-1
	2001-08-01	<9.8E-2	<1.3E-1	1.2E-1	<1.9E-1	1.3E+0	2.7E+0	2.7E-1	4.3E-1
	2001-09-05	<7.2E-2	<1.4E-1	2.5E-1	3.3E-1	1.4E+0	2.3E+0	1.1E+0	4.3E-1
	2001-10-03	<3.8E-2	<7.9E-2	<8.0E-2	<9.5E-2	1.8E+0	1.8E+0	3.6E-1	3.7E-1
	2001-10-31	<6.2E-2	8.3E-2	<8.3 E-2	3.8E-1	1.9E+0	3.1 E+0	2.2E-1	1.8E-1
	2000-11-27	<3.5E-2	<3.3E-2	2.0E-1	5.9E-1	8.3E-1	1.1E+0	4.9E-1	9.1E-2

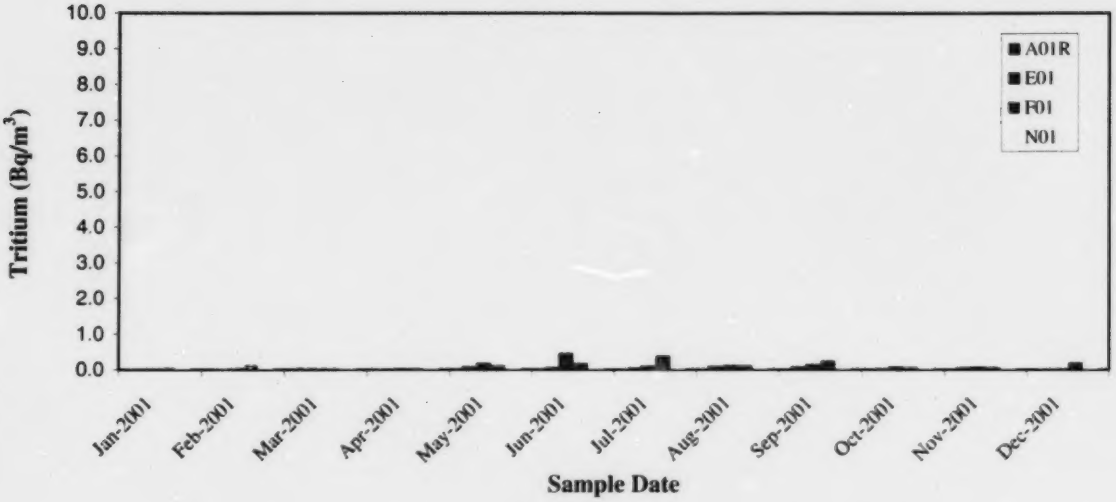

Figure 4.03: Water Vapour (Tritium) for Each Offsite Air Station

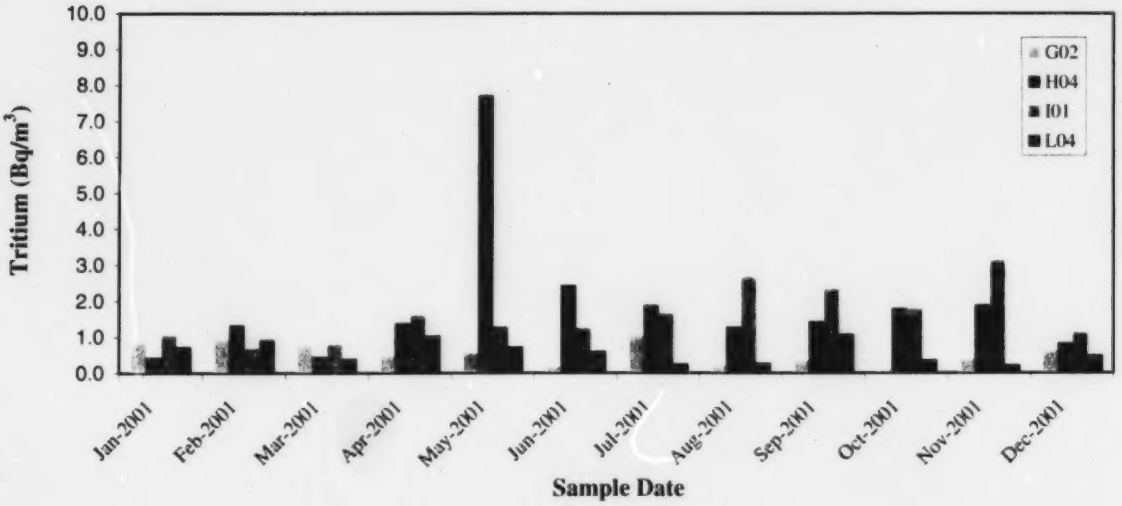

Figure 4.04: Water Vapour (Tritium) for Each Onsite Air Station

4.04 Carbon Dioxide

Carbon-14 was detected in 23 of the 23 samples from the onsite monitors and 12 of the 12 samples from the offsite monitor.

Air is monitored continuously at two onsite locations (G02 and H04 in Figure 3.02) and one reference location. The caustic bubblers are changed monthly and returned to the lab for analysis.

Individual analysis results for 2001 are given in Table 4.04. Based on stack emissions, the calculated average annual concentration of C-14 in air at the boundary fence for 2001 was approximately 8E-4 Bq/m^3 (well below the natural level of 4E-2 Bq/m^3). The results for the two onsite monitors (mean of 4.7E-2 Bq/m^3) were very similar to the reference monitor (mean of 4.8E-2 Bq/m^3). There was a significant improvement in detection limits from previous years due to a more sensitive analytical method being introduced in 2000. This decreased the LLD by a factor of ten.

Table 4.04 is the summary table of 2001 C-14 data and Table 4.05 gives details of 2001 C-14 results by location (graphically shown in Figure 4.05).

There was no monitoring at G02 for the period from 2001-09-05 to 2001-10-03 due to operator error.

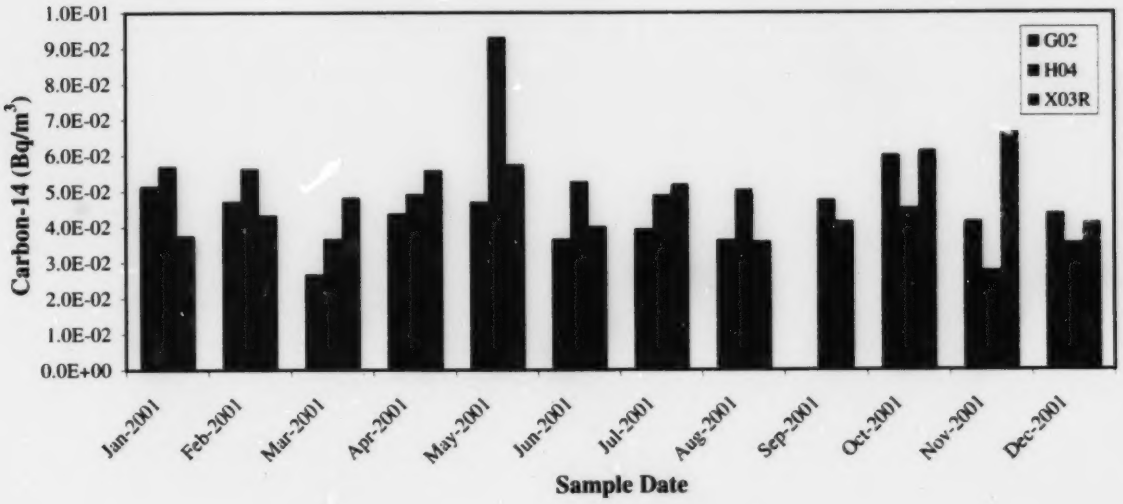

Figure 4.05: Carbon Dioxide (Carbon-14)

Table 4.04: Carbon Dioxide - Carbon-14 (Bq/m^3)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
C-14	35	2.2E-2	1.9E-2 to 3.7E-2	4.7E-2	23/23	2.7E-2 to 9.3E-2	4.8E-2	12/12	3.6E-2 to 6.6E-2

Table 4.05: Carbon Dioxide - Carbon-14 (Bq/m^3)

Location Code		***G02***	***H04***	***X03R***
Location		***Lepreau Lighthouse***	***Old Site of Information Centre***	***Fredericton Laboratory***
Distance from PLGS		***1.0 km***	***0.75 km***	***100 km***
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample	2001-01-03	5.2E-2	5.7E-2	3.8E-2
	2001-02-07	4.7E-2	5.6E-2	4.3E-2
	2001-03-14	2.7E-2	3.7E-2	4.8E-2
	2001-04-11	4.4E-2	4.9E-2	5.6E-2
	2001-05-09	4.7E-2	9.3E-2	5.8E-2
	2001-06-07	3.7E-2	5.3E-2	4.0E-2
	2001-07-04	3.9E-2	4.9E-2	5.2E-2
	2001-08-01	3.6E-2	5.0E-2	3.6E-2
	2001-09-05	NA	4.8E-2	4.2E-2
	2001-10-03	6.0E-2	4.5E-2	6.1E-2
	2001-10-31	4.2E-2	2.8E-2	6.6E-2
	2001-11-27	4.4E-2	3.5E-2	4.1E-2

NA: Data Not Available

Table 4.05: Carbon Dioxide - Carbon-14 (Bq/m^3)

Location Code		*G02*	*H04*	*X03R*
Location		*Lepreau Lighthouse*	*Old Site of Information Centre*	*Frcdericton Laboratory*
Distance from PLGS		*1.0 km*	*0.75 km*	*100 km*
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample	2001-01-03	5.2E-2	5.7E-2	3.8E-2
	2001-02-07	4.7E-2	5.6E-2	4.3E-2
	2001-03-14	2.7E-2	3.7E-2	4.8E-2
	2001-04-11	4.4E-2	4.9E-2	5.6E-2
	2001-05-09	4.7E-2	9.3E-2	5.8E-2
	2001-06-07	3.7E-2	5.3E-2	4.0E-2
	2001-07-04	3.9E-2	4.9E-2	5.2E-2
	2001-08-01	3.6E-2	5.0E-2	3.6E-2
	2001-09-05	NA	4.8E-2	4.2E-2
	2001-10-03	6.0E-2	4.5E-2	6.1E-2
	2001-10-31	4.2E-2	2.8E-2	6.6E-2
	2001-11-27	4.4E-2	3.5E-2	4.1E-2
NA: Data Not Available				

4.05 Ambient Gamma (TLD)

Gamma exposure measurements were slightly higher onsite, especially near the SRWMF and reactor building, than they were offsite.

Ambient gamma radiation is measured by thermoluminescent dosimeters (TLDs) at the 83 locations shown in Figure 3.04 plus five locations at the Hemlock Knoll Regional Sanitary Landfill (locations YTL1 to YTL5). Forty-three of these are near the Solid Radioactive Waste Management Facility. Locations I11A to I11L (formerly I00A-L) are on the perimeter fence of the SRWMF-Phase 1, and locations I21A to I21L (formerly I03A-L) are on the perimeter of the SRWMF-Phase 2. The Drop-off TLDs for SRWMF-Phase 2 are shown in Table 4.30. TLDs are changed quarterly. All but seven of the 348 dosimeters placed in the environment were recovered.

Data for 2001 are given in Table 4.06. The data in the "Total" column are rounded to the nearest ten microgray. If a quarterly measurement is not available (lost or vandalised TLD, animal damage, moisture penetration, etc.) a mean value is calculated from the available measurements in order to provide an estimate for the annual total. The statistical uncertainty shown in the Total column is the square root of the sum of the squares of the uncertainties of the individual quarterly measurements.

The variation in natural background radiation at any individual location covers a range of about 300 microgray from year to year. The locations (J70 and M02) close to the reactor building and the air emissions stack show increases in gamma radiation due to chronic releases of low levels of noble gases. Increases at the SRWMF locations are due to low-level waste and used fuel emplacement, and not to station emissions. There is a small, but undefinable, component of radiation on the TLDs at the SRWMF that is due to enhanced natural radiation from the aggregate in the concrete structures.

Figure 4.06 compares the reference location results with the results for other locations.

The range of values for the 12 TLD locations at the SRWMF - Phase 2 was from 760 to 1390 microgray per annum. The average for the facility is 890 microgray per annum - not significantly different from other low background (and natural) radiation measurements anywhere in Canada.

Nine sampling locations were discontinued and one was added in 2001. The discontinued ones were near the SRWMF. They were below the line of site to the SRWMF and were hazardous to access. The added one was in a community remote from PLGS. The area is noted for its natural uranium content. The measurement there (1460 microgray) is higher than any other location at PLGS.

Table 4.06: Ambient Gamma – TLD (μGy)

Location	Dose (μGy ± 10%)				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
A01R	134 ± 13	149 ± 15	166 ± 17	170 ± 17	**620 ± 30**
B03	135 ± 13	164 ± 16	183 ± 18	179 ± 18	**660 ± 30**
C03	126 ± 13	149 ± 15	162 ± 16	164 ± 16	**600 ± 30**
D02	134 ± 13	175 ± 18	201 ± 20	191 ± 19	**700 ± 40**
E01	150 ± 15	154 ± 15	169 ± 17	175 ± 18	**650 ± 30**
E04	101 ± 10	106 ± 11	121 ± 12	121 ± 12	**450 ± 20**
E05	193 ± 19	150 ± 15	172 ± 17	177 ± 18	**690 ± 30**
E06	213 ± 21	194 ± 19	199 ± 20	214 ± 21	**820 ± 40**
F01	122 ± 12	114 ± 11	140 ± 14	138 ± 14	**510 ± 30**
G02	188 ± 19	178 ± 18	188 ± 19	198 ± 20	**750 ± 40**
H04	143 ± 14	150 ± 15	170 ± 17	167 ± 17	**630 ± 30**
H05	113 ± 11	121 ± 12	142 ± 14	136 ± 14	**510 ± 30**
I11A	191 ± 19	205 ± 21	232 ± 22	243 ± 24	**870 ± 40**
I11B	185 ± 19	232 ± 23	246 ± 25	249 ± 25	**910 ± 50**
I11C	190 ± 19	222 ± 22	248 ± 25	242 ± 24	**900 ± 50**
I11D	179 ± 18	211 ± 21	224 ± 22	226 ± 23	**840 ± 40**
I11E	174 ± 17	215 ± 22	245 ± 24	251 ± 25	**880 ± 40**
I11F	177 ± 18	204 ± 20	233 ± 23	239 ± 24	**850 ± 40**
I11G	180 ± 18	226 ± 23	251 ± 25	252 ± 25	**910 ± 50**
I11H	182 ± 18	226 ± 23	248 ± 25	257 ± 26	**910 ± 50**
I11I	182 ± 18	238 ± 24	250 ± 25	259 ± 26	**930 ± 50**
I11J	160 ± 16	219 ± 22	235 ± 24	230 ± 23	**840 ± 40**
I11K	148 ± 15	219 ± 22	232 ± 23	249 ± 25	**850 ± 40**
I11L	159 ± 16	218 ± 22	240 ± 24	238 ± 24	**850 ± 40**
I21A	177 ± 18	193 ± 19	197 ± 20	235 ± 24	**800 ± 40**
I21B	173 ± 17	177 ± 18	198 ± 20	244 ± 24	**790 ± 40**
I21C	191 ± 19	179 ± 18	202 ± 20	207 ± 21	**780 ± 40**
I21D	266 ± 27	349 ± 35	374 ± 37	395 ± 40	**1390 ± 70**
I21E	274 ± 27	313 ± 31	339 ± 34	343 ± 34	**1270 ± 60**
I21F	182 ± 18	203 ± 20	221 ± 22	297 ± 30	**900 ± 50**
I21G	172 ± 17	174 ± 17	182 ± 18	260 ± 26	**790 ± 40**
I21H	154 ± 15	188 ± 19	204 ± 20	247 ± 25	**790 ± 40**
I21I	149 ± 15	189 ± 19	200 ± 20	258 ± 26	**800 ± 40**
I21J	170 ± 17	194 ± 19	215 ± 21	249 ± 25	**830 ± 40**
I21K	166 ± 17	197 ± 20	214 ± 21	251 ± 25	**830 ± 40**
I21L	162 ± 16	182 ± 18	199 ± 20	216 ± 22	**760 ± 40**

Table 4.06: Ambient Gamma – TLD (μGy)

Location	*Dose (μGy ± 10%)*				
	1st Quarter	*2nd Quarter*	*3rd Quarter*	*4th Quarter*	*Year*
A01R	134 ± 13	149 ± 15	166 ± 17	170 ± 17	**620 ± 30**
B03	135 ± 13	164 ± 16	183 ± 18	179 ± 18	**660 ± 30**
C03	126 ± 13	149 ± 15	162 ± 16	164 ± 16	**600 ± 30**
D02	134 ± 13	175 ± 18	201 ± 20	191 ± 19	**700 ± 40**
E01	150 ± 15	154 ± 15	169 ± 17	175 ± 18	**650 ± 30**
E04	101 ± 10	106 ± 11	121 ± 12	121 ± 12	**450 ± 20**
E05	193 ± 19	150 ± 15	172 ± 17	177 ± 18	**690 ± 30**
E06	213 ± 21	194 ± 19	199 ± 20	214 ± 21	**820 ± 40**
F01	122 ± 12	114 ± 11	140 ± 14	138 ± 14	**510 ± 30**
G02	188 ± 19	178 ± 18	188 ± 19	198 ± 20	**750 ± 40**
H04	143 ± 14	150 ± 15	170 ± 17	167 ± 17	**630 ± 30**
H05	113 ± 11	121 ± 12	142 ± 14	136 ± 14	**510 ± 30**
I11A	191 ± 19	205 ± 21	232 ± 22	243 ± 24	**870 ± 40**
I11B	185 ± 19	232 ± 23	246 ± 25	249 ± 25	**910 ± 50**
I11C	190 ± 19	222 ± 22	248 ± 25	242 ± 24	**900 ± 50**
I11D	179 ± 18	211 ± 21	224 ± 22	226 ± 23	**840 ± 40**
I11E	174 ± 17	215 ± 22	245 ± 24	251 ± 25	**880 ± 40**
I11F	177 ± 18	204 ± 20	233 ± 23	239 ± 24	**850 ± 40**
I11G	180 ± 18	226 ± 23	251 ± 25	252 ± 25	**910 ± 50**
I11H	182 ± 18	226 ± 23	248 ± 25	257 ± 26	**910 ± 50**
I11I	182 ± 18	238 ± 24	250 ± 25	259 ± 26	**930 ± 50**
I11J	160 ± 16	219 ± 22	235 ± 24	230 ± 23	**840 ± 40**
I11K	148 ± 15	219 ± 22	232 ± 23	249 ± 25	**850 ± 40**
I11L	159 ± 16	218 ± 22	240 ± 24	238 ± 24	**850 ± 40**
I21A	177 ± 18	193 ± 19	197 ± 20	235 ± 24	**800 ± 40**
I21B	173 ± 17	177 ± 18	198 ± 20	244 ± 24	**790 ± 40**
I21C	191 ± 19	179 ± 18	202 ± 20	207 ± 21	**780 ± 40**
I21D	266 ± 27	349 ± 35	374 ± 37	395 ± 40	**1390 ± 70**
I21E	274 ± 27	313 ± 31	339 ± 34	343 ± 34	**1270 ± 60**
I21F	182 ± 18	203 ± 20	221 ± 22	297 ± 30	**900 ± 50**
I21G	172 ± 17	174 ± 17	182 ± 18	260 ± 26	**790 ± 40**
I21H	154 ± 15	188 ± 19	204 ± 20	247 ± 25	**790 ± 40**
I21I	149 ± 15	189 ± 19	200 ± 20	258 ± 26	**800 ± 40**
I21J	170 ± 17	194 ± 19	215 ± 21	249 ± 25	**830 ± 40**
I21K	166 ± 17	197 ± 20	214 ± 21	251 ± 25	**830 ± 40**
I21L	162 ± 16	182 ± 18	199 ± 20	216 ± 22	**760 ± 40**

Table 4.06 (continued): Ambient Gamma – TLD (μGy)

Location	Dose (μGy ± 10%)				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
I75	186 ± 19	203 ± 20	210 ± 21	203 ± 20	**800 ± 40**
I86	144 ± 14	149 ± 15	148 ± 15	153 ± 15	**590 ± 30**
I87	134 ± 13	161 ± 16	179 ± 18	176 ± 18	**650 ± 30**
I88	145 ± 15	174 ± 17	179 ± 18	170 ± 17	**670 ± 30**
I89	141 ± 14	NA	186 ± 19	189 ± 19	**690 ± 30**
I90	123 ± 12	129 ± 13	150 ± 15	147 ± 15	**550 ± 30**
I91	145 ± 14	155 ± 16	182 ± 18	169 ± 17	**650 ± 30**
I92	127 ± 13	156 ± 16	164 ± 16	157 ± 16	**600 ± 30**
I93	131 ± 13	147 ± 15	160 ± 16	NA	**580 ± 30**
I94	159 ± 16	175 ± 18	190 ± 19	184 ± 18	**710 ± 40**
I95	129 ± 13	136 ± 14	158 ± 16	164 ± 16	**590 ± 30**
I98	126 ± 13	155 ± 15	165 ± 17	NA	**590 ± 30**
I99	155 ± 16	191 ± 19	209 ± 21	NA	**740 ± 30**
J00	141 ± 14	171 ± 17	181 ± 18	184 ± 18	**680 ± 30**
J20	171 ± 17	183 ± 18	195 ± 19	188 ± 19	**740 ± 40**
J35	245 ± 24	188 ± 19	193 ± 19	191 ± 19	**820 ± 40**
J70	283 ± 28	314 ± 31	336 ± 34	303 ± 30	**1240 ± 60**
K01	149 ± 15	195 ± 20	194 ± 19	201 ± 20	**740 ± 40**
K02	183 ± 18	194 ± 19	202 ± 20	188 ± 19	**770 ± 40**
L01	136 ± 14	170 ± 17	182 ± 18	175 ± 18	**660 ± 30**
L02	169 ± 17	230 ± 23	235 ± 23	216 ± 22	**850 ± 40**
L03	143 ± 14	154 ± 15	154 ± 15	133 ± 13	**580 ± 30**
L04	181 ± 18	199 ± 20	196 ± 20	204 ± 20	**780 ± 40**
M02	273 ± 27	263 ± 26	257 ± 26	265 ± 26	**1060 ± 50**
N01	147 ± 15	168 ± 17	168 ± 17	173 ± 17	**660 ± 30**
P01	113 ± 11	110 ± 11	119 ± 12	115 ± 12	**460 ± 20**
P03	118 ± 12	141 ± 14	161 ± 16	136 ± 14	**560 ± 30**
X12	NA	NA	351 ± 35	381 ± 38	**1460 ± 50**
YTL1	139 ± 14	137 ± 14	141 ± 14	147 ± 15	**560 ± 30**
YTL2	146 ± 15	132 ± 13	142 ± 14	131 ± 13	**550 ± 30**
YTL3	109 ± 11	114 ± 11	118 ± 12	123 ± 12	**460 ± 20**
YTL4	105 ± 11	110 ± 11	116 ± 12	119 ± 12	**450 ± 20**
YTL5	134 ± 13	154 ± 15	191 ± 19	191 ± 19	**670 ± 30**

NA :Data Not Available - Lost or destroyed TLD for this collection interval.

Table 4.06 (continued): Ambient Gamma – TLD (μGy)

Location	Dose (μGy ± 10%)				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year
I75	186 ± 19	203 ± 20	210 ± 21	203 ± 20	**800 ± 40**
I86	144 ± 14	149 ± 15	148 ± 15	153 ± 15	**590 ± 30**
I87	134 ± 13	161 ± 16	179 ± 18	176 ± 18	**650 ± 30**
I88	145 ± 15	174 ± 17	179 ± 18	170 ± 17	**670 ± 30**
I89	141 ± 14	NA	186 ± 19	189 ± 19	**690 ± 30**
I90	123 ± 12	129 ± 13	150 ± 15	147 ± 15	**550 ± 30**
I91	145 ± 14	155 ± 16	182 ± 18	169 ± 17	**650 ± 30**
I92	127 ± 13	156 ± 16	164 ± 16	157 ± 16	**600 ± 30**
I93	131 ± 13	147 ± 15	160 ± 16	NA	**580 ± 30**
I94	159 ± 16	175 ± 18	190 ± 19	184 ± 18	**710 ± 40**
I95	129 ± 13	136 ± 14	158 ± 16	164 ± 16	**590 ± 30**
I98	126 ± 13	155 ± 15	165 ± 17	NA	**590 ± 30**
I99	155 ± 16	191 ± 19	209 ± 21	NA	**740 ± 30**
J00	141 ± 14	171 ± 17	181 ± 18	184 ± 18	**680 ± 30**
J20	171 ± 17	183 ± 18	195 ± 19	188 ± 19	**740 ± 40**
J35	245 ± 24	188 ± 19	193 ± 19	191 ± 19	**820 ± 40**
J70	283 ± 28	314 ± 31	336 ± 34	303 ± 30	**1240 ± 60**
K01	149 ± 15	195 ± 20	194 ± 19	201 ± 20	**740 ± 40**
K02	183 ± 18	194 ± 19	202 ± 20	188 ± 19	**770 ± 40**
L01	136 ± 14	170 ± 17	182 ± 18	175 ± 18	**660 ± 30**
L02	169 ± 17	230 ± 23	235 ± 23	216 ± 22	**850 ± 40**
L03	143 ± 14	154 ± 15	154 ± 15	133 ± 13	**580 ± 30**
L04	181 ± 18	199 ± 20	196 ± 20	204 ± 20	**780 ± 40**
M02	273 ± 27	263 ± 26	257 ± 26	265 ± 26	**1060 ± 50**
N01	147 ± 15	168 ± 17	168 ± 17	173 ± 17	**660 ± 30**
P01	113 ± 11	110 ± 11	119 ± 12	115 ± 12	**460 ± 20**
P03	118 ± 12	141 ± 14	161 ± 16	136 ± 14	**560 ± 30**
X12	NA	NA	351 ± 35	381 ± 38	**1460 ± 50**
YTL1	139 ± 14	137 ± 14	141 ± 14	147 ± 15	**560 ± 30**
YTL2	146 ± 15	132 ± 13	142 ± 14	131 ± 13	**550 ± 30**
YTL3	109 ± 11	114 ± 11	118 ± 12	123 ± 12	**460 ± 20**
YTL4	105 ± 11	110 ± 11	116 ± 12	119 ± 12	**450 ± 20**
YTL5	134 ± 13	154 ± 15	191 ± 19	191 ± 19	**670 ± 30**

NA :Data Not Available - Lost or destroyed TLD for this collection interval.

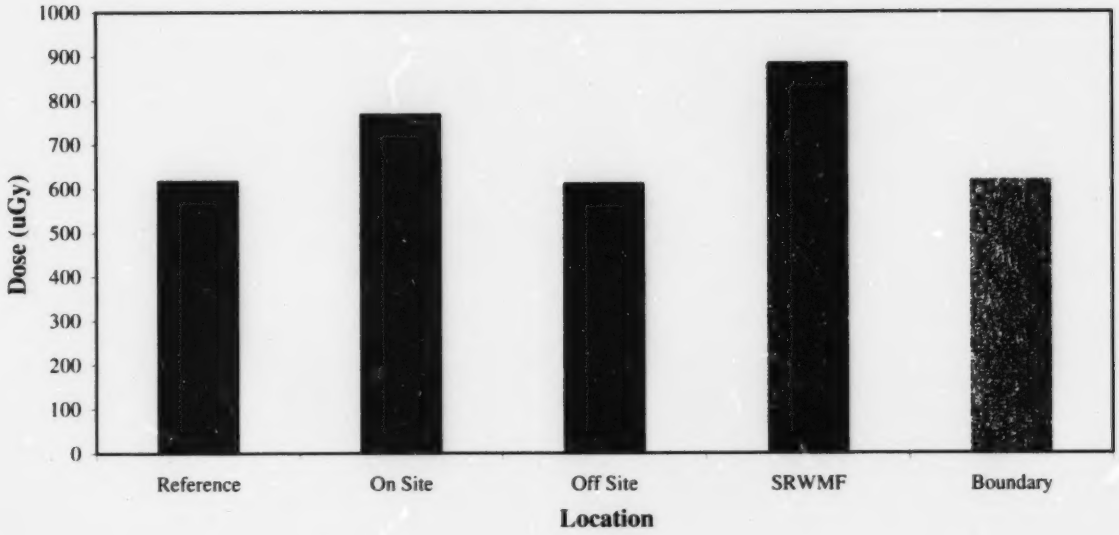

Figure 4.06: Mean TLD Results for 2001

4.06 Airborne Strontiums (GEM)

Since Sr-89,90 emissions are so low, the expected concentration in environmental samples is well below the detection limit.

The Gaseous Effluent Monitor (GEM) monitors PLGS gaseous emissions continuously at their source. The filters are changed daily and the weekly composite is sent to the lab for analysis. Fifty-three sets of these filters were analysed for Sr-89,90. If the release rate warrants, or if significant beta activity is detected in environmental air samples, a Sr-89,90 analysis is performed on those samples.

4.07 Milk

There were no detected radionuclides in milk attributable to PLGS operations.

There are no commercial herds or individual cows producing milk in the Point Lepreau area. The closest herds to PLGS are in Oak Bay (60 km distant), Fredericton Junction (70 km distant), and Hammond River (60 km distant), and the milk from these locations is analysed quarterly. Milk from a commercial dairy is purchased each month from a supermarket in Fredericton. All samples are analysed for gamma emitting radionuclides and tritium.

Table 4.07 is a summary of the detected radionuclides in milk. Tritium was detected in one of the 24 collected (23 Bq/L). This was very near the Critical Level of 12 Bq/L and is believed to be a

statistical "false positive". Cesium-137 has been detected in past years, but not in 2001. The Cs-137 originated from fallout from bomb tests and the Chernobyl accident. The cow preferentially absorbs cesium if there is a dietary deficiency in potassium. Naturally occurring radionuclides (including K-40 at about 50 Bq/L and, occasionally, progeny of uranium and thorium) are also detected in milk. As airborne emissions from PLGS are monitored continuously, and were insignificant all year, neither tritium nor gamma emitting radionuclides attributable to the operation of PLGS would be expected to be detected in these milk samples.

4.08 Well Water

No gamma emitting radionuclides other than those occurring in nature from radon progeny were detected in well water. The beta activity is due to the presence of naturally occurring radionuclides peculiar to certain locations. The H-3 in 19 of the 34 samples is most likely due to surface runoff into shallow wells. The source of this H-3 is PLGS emissions.

Water is collected semi-annually from the 12 wells shown in Figure 3.03. Two of these wells are onsite.

Table 4.08 is a summary of the detected radionuclides in well water. Figures 4.07 and 4.08 show the gross beta and H-3 results for each sample. "Less Than" values are plotted for non-detected results. The H-3 measurements were made after samples had been allowed to sit for up to two weeks to avoid radioactive interference from the relatively abundant, but short half-life, radon progeny which are common in most well waters. Tritium originates in the washout into precipitation and subsequent drainage into some of the wells. Rainwater analyses indicate H-3 concentrations ranging from 21 to 870 Bq/L in 35 of 40 samples.

The 1996 Guidelines for Canadian Drinking Water Quality recommend 7000 Bq/L as the maximum acceptable concentration for H-3 in drinking water. The highest average well water H-3 content was less than one percent of the recommended maximum concentration.

A special project (started in 2000) became part of the program in 2001. Ten additional wells are sampled once per year. These are located just outside the exclusion boundary and belong to local residents. Results are included in Table 4.08.

Table 4.07: Milk (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	24	1.3E+1	1.2E+1 to 1.4E+1	2.3E+1	1/12	2.3E+1 to 2.3E+1	*	*	*
K-40	24	2.7E+0	9.4E-2 to 3.5E+0	4.9E+1	12/12	4.6E+1 to 5.2E+1	5.1E+1	12/12	4.9E+1 to 5.4E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.07: Milk (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	24	1.3E+1	1.2E+1 to 1.4E+1	2.3E+1	1/12	2.3E+1 to 2.3E+1	*	*	*
K-40	24	2.7E+0	9.4E-2 to 3.5E+0	4.9E+1	12/12	4.6E+1 to 5.2E+1	5.1E+1	12/12	4.9E+1 to 5.4E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.08: Well Water (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Alpha	34	6.8E-2	2.1E-2 to 1.8E-1	1.5E-1	24/32	2.5E-2 to 4.5E-1	5.1E-2	2/2	5.1E-2 to 5.1E-2
Beta	34	4.5E-2	2.3E-2 to 1.1E-1	1.1E-1	27/32	3.8E-2 to 2.0E-1	7.7E-2	2/2	7.4E-2 to 8.0E-2
H-3	34	1.3E+1	1.2E+1 to 1.4E+1	2.2E+1	19/32	1.3E+1 to 4.5E+1	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.08: Well Water (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Alpha	34	6.8E-2	2.1E-2 to 1.8E-1	1.5E-1	24/32	2.5E-2 to 4.5E-1	5.1E-2	2/2	5.1E-2 to 5.1E-2
Beta	34	4.5E-2	2.3E-2 to 1.1E-1	1.1E-1	27/32	3.8E-2 to 2.0E-1	7.7E-2	2/2	7.4E-2 to 8.0E-2
H-3	34	1.3E+1	1.2E+1 to 1.4E+1	2.2E+1	19/32	1.3E+1 to 4.5E+1	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

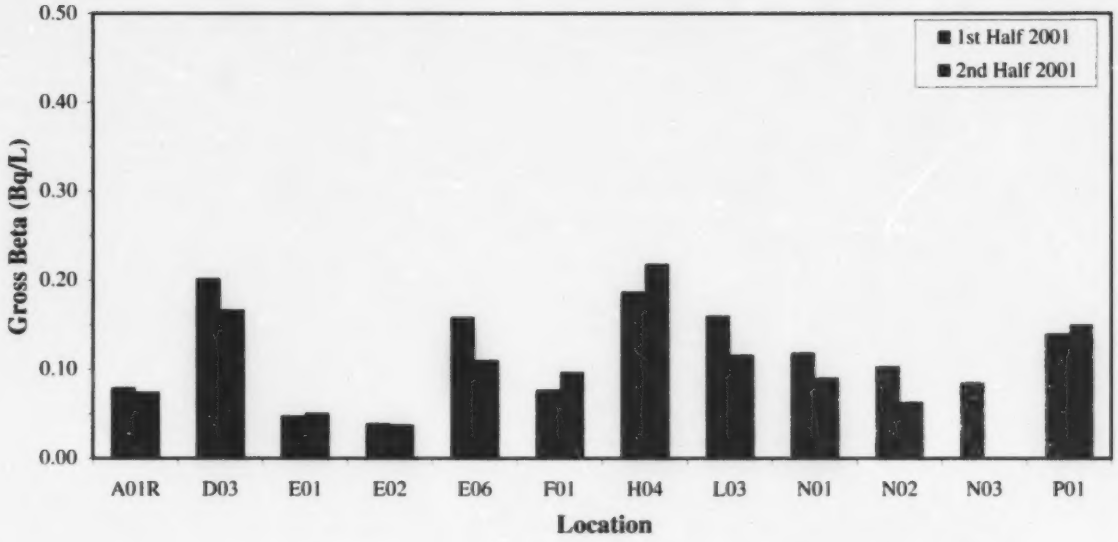

Figure 4.07: Gross Beta in Well Water

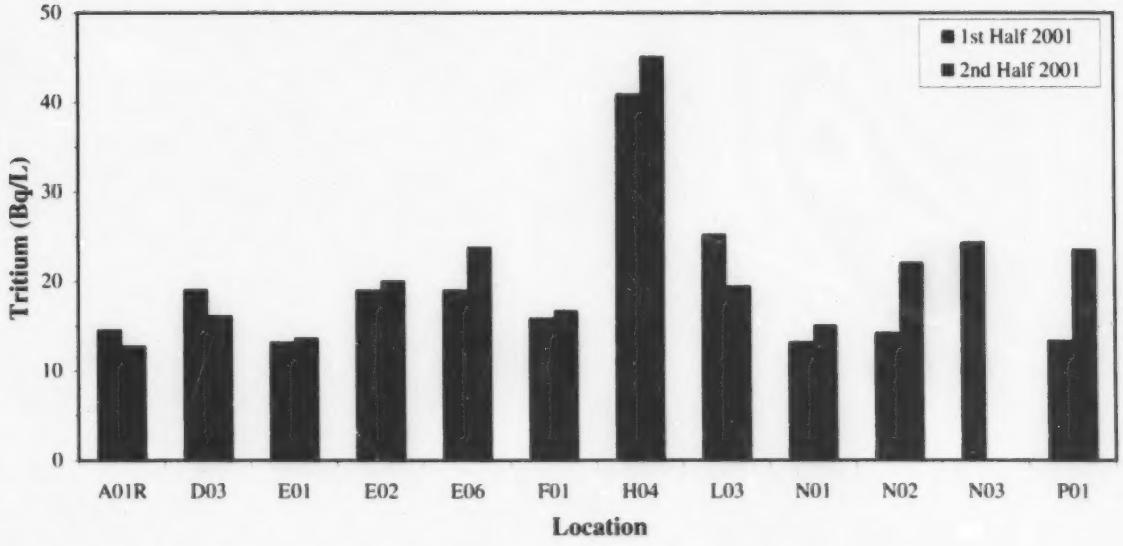

Figure 4.08: Tritium in Well Water

4.09 Pond/Puddle/Surface Water

Tritium, from PLGS emissions, was detected in 8 of the 18 samples. No other radionuclides were detected.

This category includes ponds, lakes, streams, and runoff samples. Most of these samples are from onsite locations. Two important offsite locations are the freshwater supply reservoirs for Saint John and PLGS.

Table 4.09 is a summary of the detected radionuclides in surface water. Detected H-3 activity ranged from 30 to 730 Bq/L. Variability can be due to the size of the reservoir and the residence time at the location. Figure 4.09 shows each sample (location codes are given in Appendix C). "Less Than" values are plotted for non-detected results.

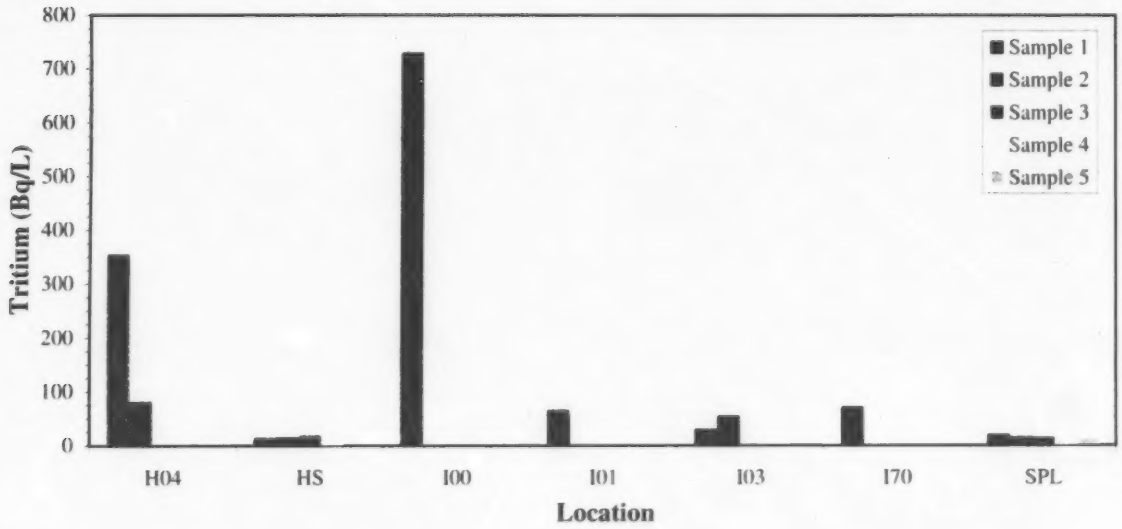

Figure 4.09: Tritium in Pond/Puddle/Surface Water

Table 4.09: Pond/Puddle/Surface Water (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	18	1.3E+1	1.2E+1 to 1.5E+1	1.8E+2	8/18	3.0E+1 to 7.3E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.10 Berries

No radionuclides attributable to PLGS emissions were detected in these 5 samples.

Most of these samples were blueberries from the commercial fields at Pennfield. Some local residents provided other species from the Lepreau Peninsula.

It is not unusual to detect Cs-137 in berries throughout North America, although none was seen this year. As in many food samples, naturally occurring K-40 was detected in five samples (see Table 4.10).

4.11 Garden Vegetables

No radionuclides attributable to PLGS emissions were detected in these 17 samples.

Most samples were taken from a local garden in Dipper Harbour (4 km away from PLGS in the predominant wind direction).

As in most food samples, naturally occurring K-40 was detected in 16 samples (see Table 4.11).

4.12 Vegetation (Lichen)

No radionuclides from PLGS were detected in these 16 samples.

Different species of lichen and moss concentrate a wide range of radionuclides, both natural (Be-7 and K-40) and man-made (Cs-137), and are sensitive indicators of radionuclides in the environment. These samples are collected whenever and wherever available from onsite locations.

Natural Be-7 was detected in all samples, and K-40 was detected in one of these samples in 2001 (Table 4.12).

Table 4.10: Berries, Various (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	5	3.5E+1	8.5E+0 to 5.3E+1	6.6E+1	5/5	4.3E+1 to 1.1E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.11: Garden Vegetables (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
K-40	17	6.6E+1	3.8E+0 to 2.5E+2	1.6E+2	16/17	5.4E+1 to 6.0E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.12: Vegetation (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	16	6.6E+1	2.4E+1 to 1.2E+2	2.0E+2	16/16	1.0E+2 to 3.1E+2	*	*	*
K-40	16	2.1E+2	2.6E+1 to 3.5E+2	1.8E+2	1/16	1.8E+2 to 1.8E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.12: Vegetation (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	16	6.6E+1	2.4E+1 to 1.2E+2	2.0E+2	16/16	1.0E+2 to 3.1E+2	*	*	*
K-40	16	2.1E+2	2.6E+1 to 3.5E+2	1.8E+2	1/16	1.8E+2 to 1.8E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.13 Soil

In 2001, there were no detectable radionuclides that could be attributed to the operation of PLGS in any of the 36 samples analysed.

Soil samples are taken quarterly from the eight air monitoring location sites.

Most samples contained naturally occurring K-40 (130 to 1000 Bq/kg), Be-7 (12 to 160 Bq/kg) and Ac-228 (15 to 81 Bq/kg). Twenty-four contained Cs-137 (2.5 to 100 Bq/kg) at typical levels for the region (see Table 4.13). Figure 4.10 shows individual Cs-137 results that seem to be a function of the organic load in the sample. "Less Than" values are plotted for non-detected results. Location codes are shown in Appendix C.

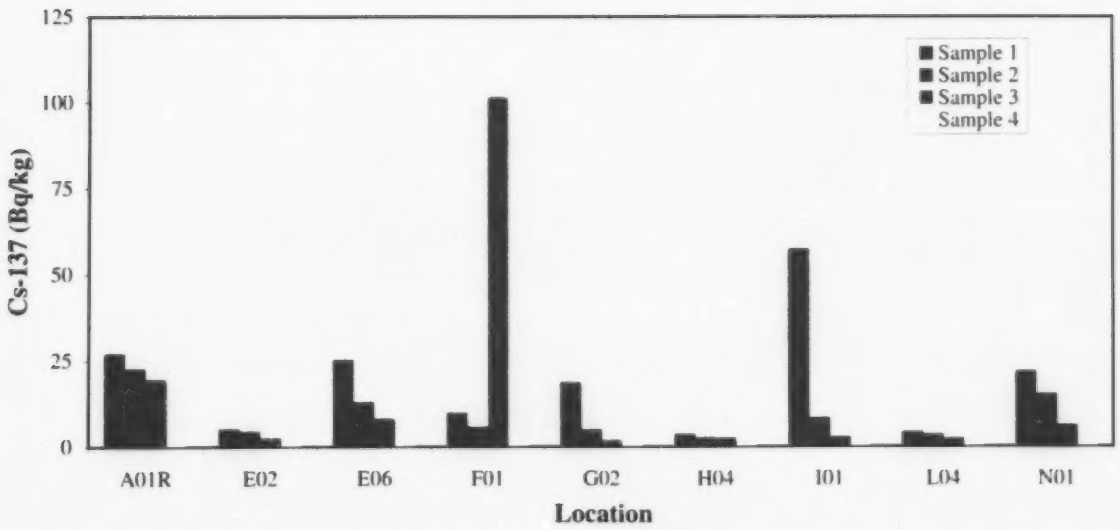

Figure 4.10: Cs-137 in Soil

Table 4.13: Soil (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	36	1.9E+1	6.5E+0 to 8.1E+1	4.1E+1	13/32	1.2E+1 to 1.6E+2	*	*	*
Cs-137	36	3.1E+0	5.9E-1 to 2.4E+1	2.1E+1	24/32	2.5E+0 to 1.0E+2	2.3E+1	4/4	2.0E+1 to 2.7E+1
Ac-228	36	6.0E+0	1.5E+0 to 2.4E+1	4.0E+1	26/32	1.5E+1 to 8.1E+1	3.4E+1	1/4	3.4E+1 to 3.4E+1
K-40	36	9.3E+1	2.4E+1 to 1.6E+2	6.1E+2	31/32	3.0E+1 to 1.0E+3	3.0E+2	3/4	1.3E+2 to 6.1E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.13: Soil (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	36	1.9E+1	6.5E+0 to 8.1E+1	4.1E+1	13/32	1.2E+1 to 1.6E+2	*	*	*
Cs-137	36	3.1E+0	5.9E-1 to 2.4E+1	2.1E+1	24/32	2.5E+0 to 1.0E+2	2.3E+1	4/4	2.0E+1 to 2.7E+1
Ac-228	36	6.0E+0	1.5E+0 to 2.4E+1	4.0E+1	26/32	1.5E+1 to 8.1E+1	3.4E+1	1/4	3.4E+1 to 3.4E+1
K-40	36	9.3E+1	2.4E+1 to 1.6E+2	6.1E+2	31/32	3.0E+1 to 1.0E+3	3.0E+2	3/4	1.3E+2 to 6.1E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.14 Rain Water

Tritium from PLGS was detected in 35 of 40 onsite samples.

Rainwater is collected continuously at the four onsite air monitoring stations (shown in Figure 3.02). The samples are changed approximately monthly, depending on rainfall and freeze up.

Detected H-3 levels spanned 21 to 870 Bq/L, depending on the amount of rainfall. Naturally occurring Be-7 was also detected in two of the 40 samples (2.1 to 5.0 Bq/L). Results are given in Table 4.14 and shown in Figure 4.11. "Less Than" values are plotted for non-detected results.

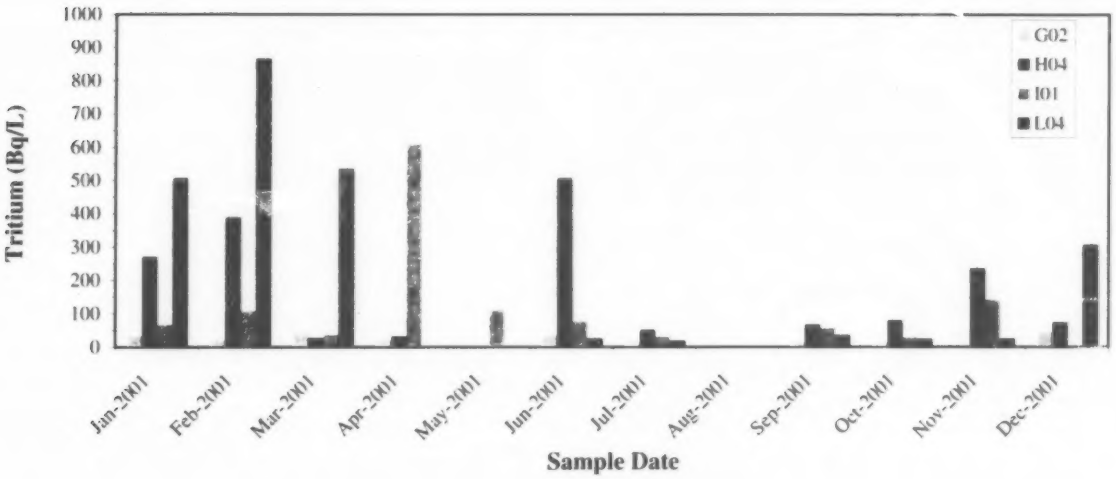

Figure 4.11: Tritium in Rain Water

4.15 Monitoring Wells (Near Plant)

In the summer of 2000, a geotechnical firm evaluated the onsite groundwater movement and made recommendations for an improved monitoring program. Based on their advice, nine new monitoring wells in and around the SRWMF and eleven new monitoring wells near the plant were drilled. bringing the total to 35. In the fall of 2001, the CNSC inspected these new wells and met with NB Power's hydrogeologists. An enhanced monitoring program was established to give a better understanding of groundwater movement.

Of the 11 new monitoring wells near the plant, 10 of these were sampled before freeze up. Tritium from PLGS was detected in 10 of the 10 samples analysed. No other radionuclides attributable to the operation of PLGS were detected. Tritium concentrations averaged 440 Bq/L, ranging up to 1.5E+03 Bq/L. Results are given in Tables 4.15.

Tritium levels in the groundwater are decreasing, or are currently at a level below regulatory concern. The impact from current levels on humans and the environment is negligible.

4.16 Seawater

In 2001, H-3 was the only detectable radionuclide that could be attributed to the operation of PLGS. It was found in one of the 16 samples analysed (29 Bq/L).

Seawater is collected quarterly from three locations close to PLGS and one reference location near Saint John (shown in Figure 3.05).

In past years, H-3 from PLGS and K-40 from nature have been detected. As seen in Table 4.16, the only radionuclides detected in 2001 were H-3 and K-40. The Critical Level for H-3 in seawater averages about 13 Bq/L. Calculations suggest that the long term average concentration of tritium in seawater due to releases from PLGS in the liquid pathway was about 70 Bq/L at the out-fall (samples are not usually collected at this point, but are taken at the shoreline nearby). This calculation takes into account the total tritium released over the year, the flow rate of the condenser cooling water (about 24 m^3/s), and tidal mixing. A dilution factor of 20 is assumed for tidal mixing at the out-fall during normal coolant flows. For collection further away, a tidal mixing factor of about 40 or even higher, is more realistic. A factor of 40 would result in an average H-3 concentration of about 11 Bq/L of seawater in 2001 at the H03 location.

Table 4.14: Rain Water (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	40	1.3E+1	1.2E+1 to 1.4E+1	1.6E+2	35/40	2.1E+1 to 8.7E+2	*	*	*
Be-7	40	3.6E+0	1.6E+0 to 5.1E+0	3.6E+0	2/40	2.1E+0 to 5.0E+0	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.14: Rain Water (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	40	1.3E+1	1.2E+1 to 1.4E+1	1.6E+2	35/40	2.1E+1 to 8.7E+2	*	*	*
Be-7	40	3.6E+0	1.6E+0 to 5.1E+0	3.6E+0	2/40	2.1E+0 to 5.0E+0	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.15: Monitoring Wells – Near Plant (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	10	1.3E+1	1.3E+1 to 1.4E+1	4.4E+2	10/10	6.0E+1 to 1.5E+3	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.16: Seawater (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	16	1.3E+1	1.2E+1 to 1.7E+1	2.9E+1	1/12	2.9E+1 to 2.9E+1	*	*	*
K-40	16	2.7E+0	8.9E-1 to 6.1E+0	1.0E+1	12/12	5.1E+0 to 1.4E+1	8.6E+0	4/4	4.6E+0 to 1.1E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.16: Seawater (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	16	1.3E+1	1.2E+1 to 1.7E+1	2.9E+1	1/12	2.9E+1 to 2.9E+1	*	*	*
K-40	16	2.7E+0	8.9E-1 to 6.1E+0	1.0E+1	12/12	5.1E+0 to 1.4E+1	8.6E+0	4/4	4.6E+0 to 1.1E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.17 Clams

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.17). No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2001.

The nature of the fishery has changed over the last few years. The inshore fishery often faces restrictions placed upon the harvesting of shellfish, either for conservation of stocks or because of bacterial contamination, algal blooms, or other natural cycles. This restricts the availability of some sample types for analysis. Sample locations are shown in Figure 3.05.

4.18 Fish

One sample was available for analysis in 2001 (see Table 4.18). The nature of the fishery has changed since the 1980s. Herring and mackerel, which used to make up the bulk of the analyses, are now less available for analysis. The fish category now tends to be made up of dogfish, cod, hake and sardines, if they are available at all.

4.19 Lobster

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.19). No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2001, even though several of the samples were collected close to the cooling water outflow from PLGS (Figure 3.05).

4.20 Periwinkles

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.20). No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2001. Sample locations are shown in Figure 3.05.

4.21 Aquaculture Salmon

The aquaculture salmon industry is important to the area west of PLGS. As well, in 2001, a new site was added in Welch Cove. Potassium-40 was detected in all of these samples (see Table 4.21). As liquid emissions from PLGS are monitored continuously, and were insignificant all year, no radionuclides attributable to the operation of PLGS would be expected to be detected in these samples.

Table 4.17: Clams, Edible Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	12	5.7E+1	1.7E+1 to 1.3E+2	2.3E+2	12/12	1.1E+2 to 7.9E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.18: Fish, Various, Edible, Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	1	5.4E+1	5.4E+1 to 5.4E+1	1.6E+2	1/1	1.6E+2 to 1.6E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.19: Lobster, Edible, Cooked Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	8	2.8E+1	7.7E+0 to 5.9E+1	7.4E+1	7/8	5.4E+1 to 8.7E+1	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.20: Periwinkles, Edible, Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	11	7.3E+1	1.9E+1 to 1.2E+2	1.4E+2	10/11	1.1E+2 to 2.0E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.21: Aquaculture Salmon, Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	5	3.5E+1	2.6E+1 to 4.6E+1	1.3E+2	5/5	8.6E+1 to 1.7E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.22 Scallops

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.22). No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2001.

The inshore fishery often faces restrictions or total bans placed upon the harvesting of scallops for conservation of stocks. This affects the number of samples available for analysis.

4.23 Crab

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.23). Scallops may also contain detectable quantities of Ac-228. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2001.

Most years, there is no active crab fishery in the local area. Only one sample was obtained this year.

4.24 Dulse

Most of the seafood analysed in the environmental program contain detectable levels of K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2001 (see Table 4.24).

Dulse is an edible seaweed that is a popular snack food in the area. Nine samples were collected in 2001 at locations shown in Figure 3.05.

4.25 Other Sea Plants

All of the sea plants analysed in the environmental program contain K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2001.

Sea plants other than dulse are analysed. Various species of seaweed (for example, *Ascophylum*) occur on the rocks on the Point Lepreau peninsula and are collected from time to time. Three of the 12 samples collected contained Be-7, a cosmogenic radionuclide. All contained naturally occurring K-40 at an average of 230 Bq/kg (see Table 4.25).

Table 4.22: Scallops, Edible, Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	3	2.4E+1	8.2E+0 to 5.1E+1	1.6E+2	3/3	1.3E+2 to 2.2E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.23: Crab, Wet Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	1	1.9E+2	1.9E+2 to 1.9E+2	5.6 E+2	1/1	5.6E+2 to 5.6E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.24: Dulse, Wet Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	9	1.4E+2	1.4E+1 to 2.6E+2	4.7E+2	9/9	2.8E+2 to 8.1E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.25: Sea Plants Wet Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	12	6.5E+0	3.5E+0 to 1.1E+1	9.9E+0	3/12	7.7E+0 to 1.4E+1	*	*	*
K-40	12	4.8E+1	3.1E+1 to 6.7E+1	2.3E+2	12/12	1.3E+2 to 3.3E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.25: Sea Plants Wet Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	12	6.5E+0	3.5E+0 to 1.1E+1	9.9E+0	3/12	7.7E+0 to 1.4E+1	*	*	*
K-40	12	4.8E+1	3.1E+1 to 6.7E+1	2.3E+2	12/12	1.3E+2 to 3.3E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.26 Sediment

No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2001.

Sediments are collected quarterly from ten locations (shown in Figure 3.05). All samples contain radioactivity from naturally occurring radionuclides (K-40 from the natural potassium in feldspar, a common mineral) and from the diminishing levels of Cs-137 fallout from bomb tests since the 1950s. A small additional Cs-137 component from Chernobyl was added to this reservoir in 1986. Actinium-228 (radioactive progeny of naturally occurring Th-232), and Be-7 (of cosmogenic origin) commonly occur in sediments. Finer grain sediments have a higher radioactivity content than coarse sediments.

See Table 4.26 for a summary of the data. Figure 4.12 shows the Cs-137 concentration for each location. "Less Than" values are plotted for non-detected results. Location codes are listed in Appendix C

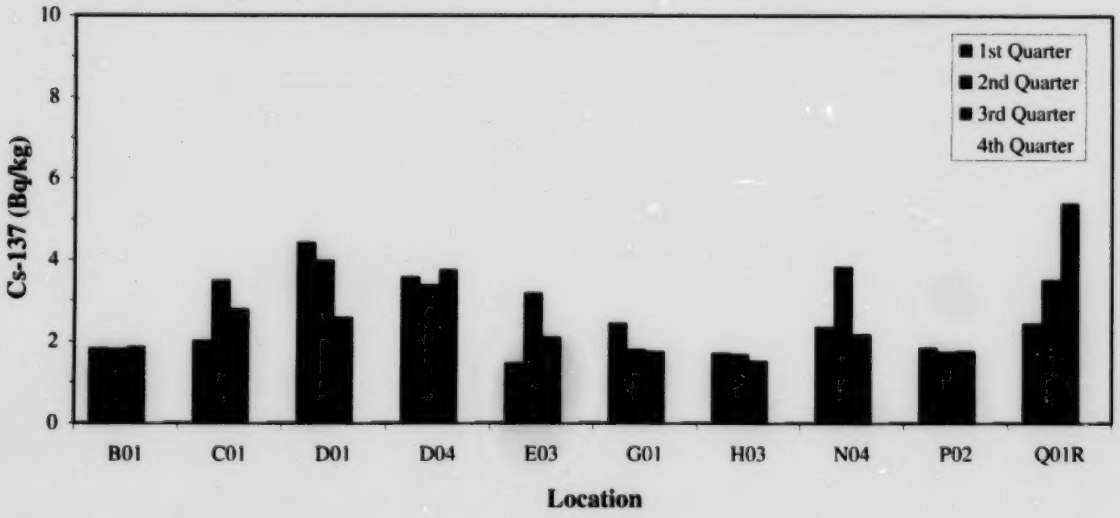

Figure 4.12: Cs-137 in Sediment

Table 4.26: Sediment (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	40	9.5E+0	4.9E+0 to 1.7E+1	2.0E+1	16/36	6.6E+0 to 3.9E+1	3.3E+1	4/4	1.2E+1 to 5.9E+1
Cs-137	40	1.2E+0	6.0E-1 to 2.7E+0	3.1E+0	7/36	2.4E+0 to 3.8E+0	2.6E+0	1/4	2.6E+0 to 2.6E+0
Ac-228	40	3.0E+0	6.6E-1 to 5.1E+0	2.5E+1	32/36	1.0E+1 to 5.4E+1	2.7E+1	3/4	2.4E+1 to 3.2E+1
K-40	40	7.9E+1	6.3E+0 to 1.3E+2	5.4E+2	36/36	4.3E+2 to 7.6E+2	5.4E+2	4/4	4.6E+2 to 6.3E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.26: Sediment (Bq/kg)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
Be-7	40	9.5E+0	4.9E+0 to 1.7E+1	2.0E+1	16/36	6.6E+0 to 3.9E+1	3.3E+1	4/4	1.2E+1 to 5.9E+1
Cs-137	40	1.2E+0	6.0E-1 to 2.7E+0	3.1E+0	7/36	2.4E+0 to 3.8E+0	2.6E+0	1/4	2.6E+0 to 2.6E+0
Ac-228	40	3.0E+0	6.6E-1 to 5.1E+0	2.5E+1	32/36	1.0E+1 to 5.4E+1	2.7E+1	3/4	2.4E+1 to 3.2E+1
K-40	40	7.9E+1	6.3E+0 to 1.3E+2	5.4E+2	36/36	4.3E+2 to 7.6E+2	5.4E+2	4/4	4.6E+2 to 6.3E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.27 Gamma Surveys (Beaches)

Environmental gamma survey measurements are made in the inter-tidal zone on beaches in the Point Lepreau area and at the reference location 28 km to the east-northeast (Figure 3.05). Although TLDs are preferred in measuring such exposures since they span the entire year and provide integrated measurements, they cannot be used in these locations. Radiation values measured in 2001 were consistent with those measured prior to station start-up in 1982. These are summarised in Table 4.27

Table 4.27: Beach Surveys - Inter-tidal Zone - Ion Chamber (μSv/h)

Location	*1st Quarter**	*2nd Quarter**	*3rd Quarter**	*4th Quarter**
B01	0.12	0.10	0.10	0.10
C01	0.11	0.10	0.09	0.10
D01	0.10	0.10	0.09	0.10
D04	0.10	0.09	0.09	0.12
E03	0.10	0.11	0.08	0.10
G01	0.12	0.16	0.09	0.12
H03	0.12	0.12	0.12	0.11
N04	0.11	0.11	0.10	0.11
P02	0.08	0.10	0.11	0.11
Q01R	0.10	0.09	0.09	0.08

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated at each location. They should be regarded as about 0.1 to 0.2 μSv/h.

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Table 4.27: Beach Surveys - Inter-tidal Zone - Ion Chamber (μSv/h)

Location	*1st Quarter**	*2nd Quarter**	*3rd Quarter**	*4th Quarter**
B01	0.12	0.10	0.10	0.10
C01	0.11	0.10	0.09	0.10
D01	0.10	0.10	0.09	0.10
D04	0.10	0.09	0.09	0.12
E03	0.10	0.11	0.08	0.10
G01	0.12	0.16	0.09	0.12
H03	0.12	0.12	0.12	0.11
N04	0.11	0.11	0.10	0.11
P02	0.08	0.10	0.11	0.11
Q01R	0.10	0.09	0.09	0.08

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated at each location. They should be regarded as about 0.1 to 0.2 μSv/h.

4.28 Liquid Strontiums (LEM)

Since Sr-89,90 releases are so low, the expected concentration in environmental samples is well below the detection limit.

The Liquid Effluent Monitor (LEM) before their release measures PLGS liquid emissions. A monthly composite is sent to the lab for analyses. Twelve of these composites were analysed for Sr-89,90. If the release rate warrants, a Sr-89,90 analysis is performed on seawater samples.

Strontium-90 was detected in several of these LEM samples at a level close to the detection limit. This translated into 4.8E+05 Bq released in 2001, compared with an annual DEL of 1.8E+14 Bq. No further analyses were indicated. See Figure 4.13.

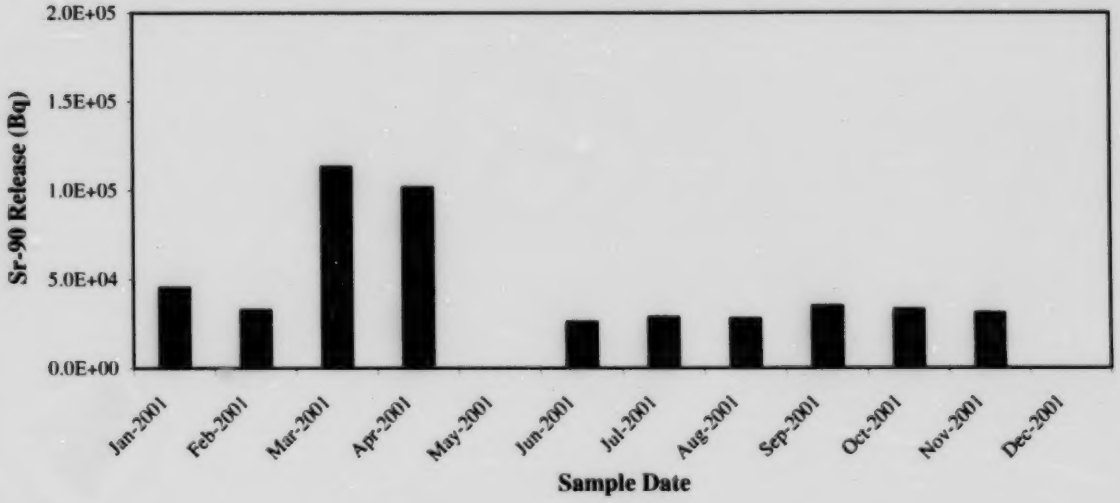

Figure 4.13: Sr-90 Releases (measured at source)

4.29 Bore Hole Water (SRWMF)

In the summer of 2000, a geotechnical firm evaluated the onsite groundwater movement and made recommendations for an improved monitoring program. Based on their advice, seven new monitoring wells in and around the SRWMF and eleven new monitoring wells near the plant were drilled, bringing the total to 35. In the fall of 2001, the CNSC inspected these new wells and met with NB Power's hydrogeologists. An enhanced monitoring program was established to give a better understanding of groundwater movement.

Tritium from PLGS was detected in 45 of the 46 samples analysed. No other radionuclides attributable to the operation of PLGS were detected.

Water from 17 bore holes on the SRWMF site (Phase 1 and 2) are collected in the second, third and fourth quarters (a total of 51 samples, if all contain sufficient water to be sampled). Nine new holes were drilled late in 2001, and two were retired due to damage. Eight of these were sampled before freeze up.

Tritium concentrations averaged 81 Bq/L, ranging up to 300 Bq/L. Tritium originates in the washout into precipitation and subsequent drainage into some of the bore holes (rainwater analyses indicate H-3 concentrations ranging from 21 to 870 Bq/L in 45 of 46 samples). Contamination of some of the bore holes by surface runoff is unavoidable when the bore holes are first opened because of standing-water covering the well cap. See Tables 4.28 and 4.29. Figure 4.14 shows the H-3 activity at each bore hole for each sample. Locations I10A-I10E are the closest to the SRWMF- Phase 1 structures and may be affected by the higher H-3 levels associated with them. "Less Than" values are plotted for non-detected results.

Tritium levels in the groundwater are decreasing, or are currently at a level below regulatory concern. The impact from current levels on humans and the environment is negligible.

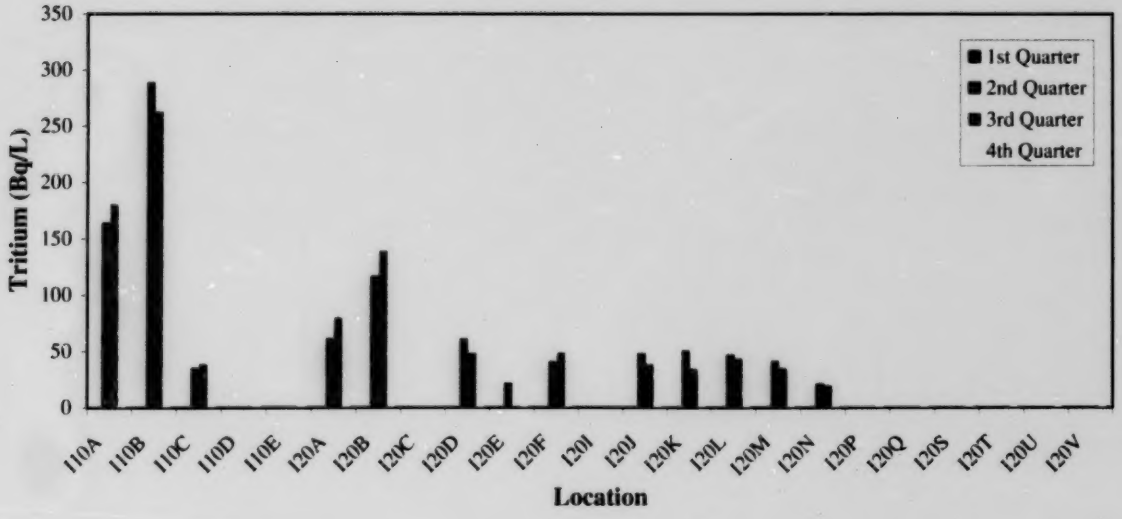

Figure 4.14: Tritium in Bore Holes

Table 4.28: Bore Hole Water SRWMF - Phase 1 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	11	1.3E+1	1.3E+1 to 1.5E+1	1.6E+2	11/11	3.5E+1 to 3.0E+2	*	*	*

*There are no Reference Stations for this sample type.

Table 4.29: Bore Hole Water SRWMF - Phase 2 (Bq/L)

Analysis Type	*Total Number*	*Critical Level*		*Indicator Stations*			*Reference Station*		
		Mean	*Range*	*Mean*	*Frequency*	*Range*	*Mean*	*Frequency*	*Range*
H-3	35	1.4E+1	1.2E+1 to 1.5E+1	5.6E+1	34/35	2.0E+1 to 2.2E+2	*	*	*

*There are no Reference Stations for this sample type.

4.30 Parshall Flume (SRWMF)

Tritium from PLGS was detected in 97 of 104 samples reaching 2.5E+03 Bq/L, with a mean value of about 3.3E+02 Bq/L. No other radionuclides attributable to the operation of PLGS were detected.

Rainwater at the SRWMF (Phase 1 and 2) is obtained from drainage channels (flumes) constructed to collect surface runoff from these areas. Samples are collected and analysed on a weekly basis. There is little or no flow into or out of these collection locations during the winter months and values for H-3 tend to vary little from one week to the next except after heavy rain. The average value at Phase 2 is 5.1E+01 Bq/L, much less than 5.8E+02 Bq/L at Phase 1. This indicates possible groundwater dilution of the surface runoff to the flume or a developing problem with the Phase 1 structures. See Tables 4.30 and 4.31. Figure 4.15 compares the H-3 in the samples from the two facilities.

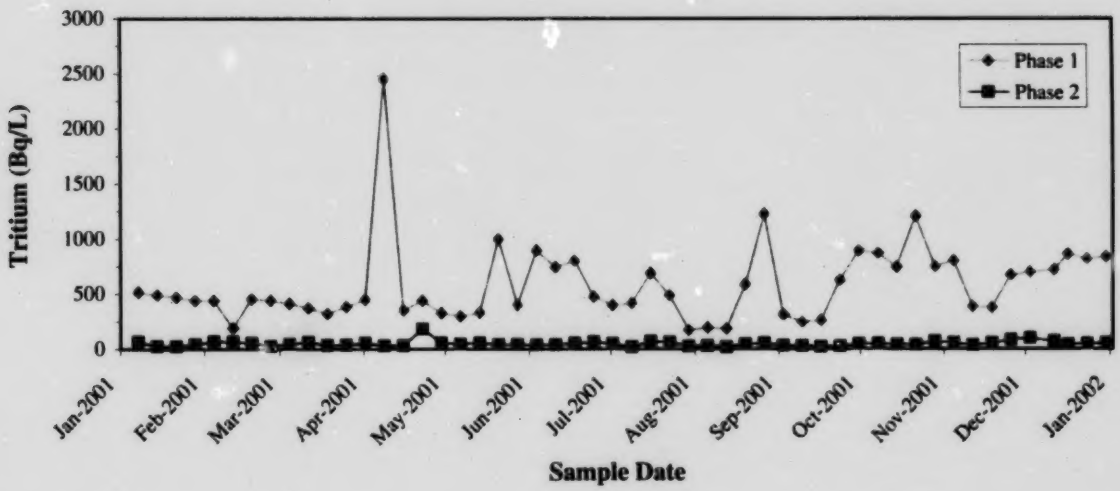

Figure 4.15: Tritium in Parshall Flumes

Table 4.30: Parshall Flume SRWMF - Phase 1 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	52	1.3E+1	1.1E+1 to 1.5E+1	5.8E+2	52/52	1.7E+2 to 2.5E+3	*	*	*

* There are no Reference Stations for this sample type.

Table 4.31: Parshall Flume SRWMF - Phase 2 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	52	1.3E+1	1.1E+1 to 1.4E+1	5.1E+1	45/52	2.3E+1 to 1.8 E+2	*	*	*

* There are no Reference Stations for this sample type.

4.31 Drop-off TLDs (SRWMF - Phase 2)

The measured radiation decreases as the distance from the SRWMF - Phase 2 increases.

Dosimeters are placed in two directions from the boundary fence of Phase 2 to measure drop-off of radiation with distance from the filled dry fuel storage canisters, to about 200 metres. Results are presented in Table 4.32. Three TLDs were lost/damaged during the first quarter.

There were 90 concrete canisters filled to the end of 2001 with 48 600 used-fuel bundles. Radiation drop-off measurements (Figure 4.16) with increasing distance away from the fence show distinct differences. The 'A' direction (mostly swamp after 20 m from the fence) covers drop-off to the northeast away from the perimeter fence. The 'B' direction (mostly rock with some shallow sandy overburden) covers drop-off to the northwest away from the perimeter (after 75 m the TLDs are shielded from the facility by the high ground).

The TLD locations furthest from the facility in the "B" direction (B9 and B10) were discontinued in 2001. They are hazardous for personnel to access. Since they are shielded from the facility by high ground, they provide limited useful information.

Table 4.32: TLD, Drop-off (μGy)

	Dose (μGy ± 10%)				
Location	***1st Quarter***	***2nd Quarter***	***3rd Quarter***	***4th Quarter***	***Year***
A 5m	175 ± 17	218 ± 22	213 ± 21	300 ± 30	**910 ± 50**
A 10m	164 ± 16	212 ± 21	222 ± 22	285 ± 29	**880 ± 50**
A 15m	144 ± 14	179 ± 18	193 ± 19	278 ± 28	**790 ± 40**
A 20m	113 ± 11	119 ± 12	136 ± 14	225 ± 23	**590 ± 30**
A 25m	103 ± 10	109 ± 11	123 ± 12	196 ± 20	**530 ± 30**
A 50m	NA	97 ± 10	113 ± 11	144 ± 14	**470 ± 20**
A 75m	NA	100 ± 10	120 ± 12	136 ± 14	**470 ± 20**
A 100m	NA	89 ± 9	106 ± 11	121 ± 12	**420 ± 20**
A 118m	149 ± 15	114 ± 11	134 ± 13	145 ± 15	**540 ± 30**
B 5m	252 ± 25	276 ± 28	301 ± 30	331 ± 33	**1160 ± 60**
B 10m	233 ± 23	255 ± 25	275 ± 27	305 ± 31	**1070 ± 50**
B 15m	177 ± 18	201 ± 20	249 ± 25	272 ± 27	**900 ± 50**
B 20m	186 ± 19	203 ± 20	230 ± 23	267 ± 27	**890 ± 40**
B 25m	176 ± 18	206 ± 21	227 ± 23	242 ± 24	**850 ± 40**
B 50m	153 ± 15	173 ± 17	203 ± 20	229 ± 23	**760 ± 40**
B 75m	143 ± 14	162 ± 16	172 ± 17	192 ± 19	**670 ± 30**
B 100m	180 ± 18	185 ± 18	204 ± 20	220 ± 22	**790 ± 40**
B 150m	143 ± 14	163 ± 16	198 ± 20	Suspended	**670 ± 30**
B 200m	152 ± 15	175 ± 18	181 ± 18	Suspended	**680 ± 30**

NA: Data Not Available - Lost or destroyed TLD for this collection interval.

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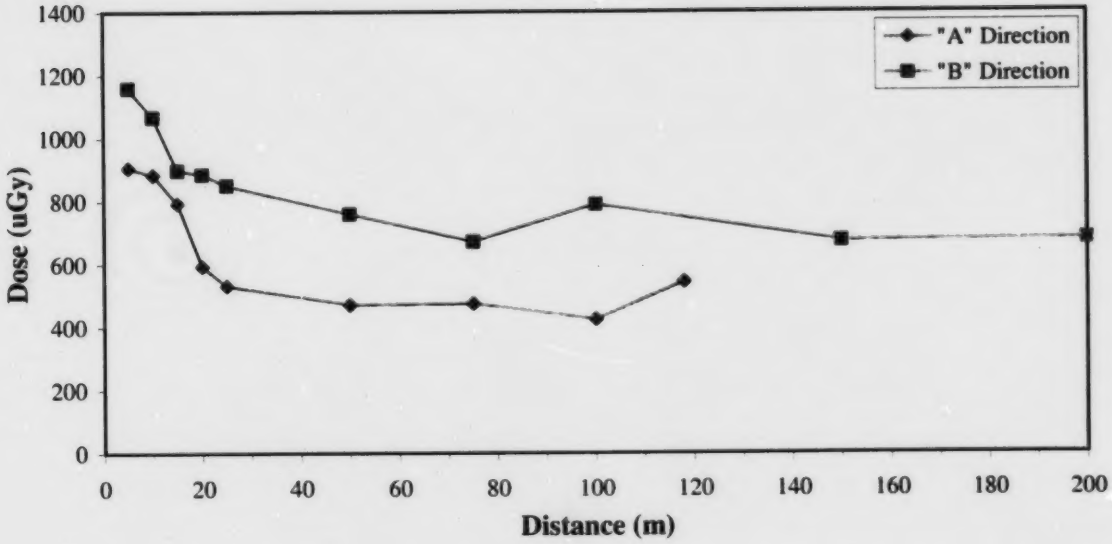

Figure 4.16: Drop-off TLDs

4.32 Hemlock Knoll Regional Sanitary Landfill

In December 1999, PLGS began disposing of its non-active waste at the public landfill facility. A monitoring program was established prior to the first shipment. It includes sampling of water from the leachate, bore holes and various holding ponds; sampling of the soil and gamma surveys of the disposal cell surface; and dosimeter placement at key locations.

There were 95 water samples, 10 soil samples, 10 gamma meter measurements and 20 TLD results. Tritium was detected in 16 of the 95 water samples. Cesium-137 was detected in two of the ten soil samples. Table 4.33 summarises the gamma survey results and Tables 4.34 and 4.35 summarises the water and soil sample results. There were no other radionuclides detected, other than naturally occurring isotopes that are not reported here. TLD results appear in Table 4.06 (location codes YTL1 to YTL5).

The leachate from Crane Mountain Regional Sanitary Landfill was analysed and found to have similar H-3 levels. PLGS does not ship waste to this facility. The source of H-3 in both of these landfills is suspected to be H-3 in commercial and consumer devices (e.g., H-3 powered "Exit" signs).

Due to the hazard to field personnel, soil and gamma surveys from the disposal cell were discontinued in 2001. Since fresh soil is used to cover the cell, no useful information was obtained.

Table 4.33: Gamma Surveys - Hemlock Knoll Regional Sanitary Landfill Ion Chamber (μSv/h)

Location	*1st Quarter**	*2nd Quarter**	*3rd Quarter**	*4th Quarter**
YODC1	0.11	0.13	Suspended	
YODC2	NA	0.11	Suspended	
YODC3	0.12	0.15	Suspended	
YODC4	NA	0.10	Suspended	
YODC5	NA	0.14	Suspended	
YODC6	NA	0.10	Suspended	
YYW1	NA	0.18	Suspended	
YYW2	NA	0.17	Suspended	

NA: Data Not Available

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Location	*1st Quarter**	*2nd Quarter**	*3rd Quarter**	*4th Quarter**
YODC1	0.11	0.13	Suspended	
YODC2	NA	0.11	Suspended	
YODC3	0.12	0.15	Suspended	
YODC4	NA	0.10	Suspended	
YODC5	NA	0.14	Suspended	
YODC6	NA	0.10	Suspended	
YYW1	NA	0.18	Suspended	
YYW2	NA	0.17	Suspended	

NA: Data Not Available

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated at each location. They should be regarded as about 0.1 to 0.2 μSv/h.

Table 4.34: Liquid (Bq/L) Hemlock Knoll Regional Sanitary Landfill

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	95	6.3E+1	5.7E+1 to 8.6E+1	2.3E+2	16/95	6.5E+1 to 6.1E+2	*	*	*

* There are no Reference Stations for this sample type.

Table 4.35: Solid (Bq/kg) Hemlock Knoll Regional Sanitary Landfill

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Cs-137	10	8.3E-1	6.8E-1 to 1.2E+0	1.8E+0	2/10	1.5E+0 to 2.0E+0	*	*	*

* There are no Reference Stations for this sample type.

4.33 Meteorological Data

A problem was discovered in the meteorological data for the years 1992 to 2000: the temperature reading from the 42-metre elevation (at the Point Lepreau Generating Station tower) contained a bias that affected the calculation of the Pasquill Stability factor. This has no affect on the program. It is presented here for information purposes only.

The meteorological data for 2001, and a compilation of the available 1986 to 2001 data, have this information removed and are presented in Tables 4.36 and 4.37 Data were collected hourly. Wind Rose data for 2001 are presented in Figure 4.17 and a pie-plot of the average percentage frequency of Pasquill stability classes for the years from 1986 to 1991 in the Point Lepreau area is presented in Figure 4.18.

Table 4.36: Meteorological Data for Point Lepreau (2001)

	Temperature (Degrees Celsius) 10 Metre Tower Data					*Wind Direction* (Relative %) 42 Metre Tower Data*							
		Mean Daily		*Extreme*		*%Observations from*							
Month	*Avg*	*Max*	*Min*	*Max*	*Min*	*N*	*NE*	*E*	*SE*	*S*	*SW*	*W*	*NW*
January	-5.6	-1.6	-9.9	3.0	-16.9	18	8	3	1	5	10	18	36
February	-4.9	-1.0	-9.5	7.0	-18.6	11	9	5	4	13	7	28	23
March	-1.0	2.1	-4.2	8.8	-18.6	19	18	1	3	8	19	19	13
April	3.5	7.1	0.7	12.7	-3.4	14	15	3	8	13	12	11	25
May	9.3	13.6	5.9	25.7	-0.1	18	20	5	9	20	15	7	6
June	13.6	17.8	10.2	26.6	7.4	3	19	6	10	22	22	10	7
July	14.0	17.9	11.4	22.7	8.8	2	11	7	17	20	29	8	5
August	16.2	20.2	13.3	25.9	10.1	8	9	3	12	26	26	9	6
September	13.6	17.5	10.2	24.4	4.6	8	13	6	12	17	19	11	14
October	9.9	12.9	6.8	19.6	-1.2	4	8	3	9	22	22	18	13
November	5.3	8.0	2.2	13.1	-4.6	13	7	5	15	17	9	19	16
December	1.4	4.0	-1.8	12.2	-7.3	12	8	6	2	6	22	27	17
Annual	Mean 6.5	Mean 10.0	Mean 3.1	Extreme 26.6	Extreme -18.6	11	12	4	9	16	18	15	15
Years	1	1	1	1	1	1	1	1	1	1	1	1	1

*Each compass direction covers ±22.5 degrees

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Month	*Avg*	*Max*	*Min*	*Max*	*Min*	*N*	*NE*	*E*	*SE*	*S*	*SW*	*W*	*NW*
January	-5.6	-1.6	-9.9	3.0	-16.9	18	8	3	1	5	10	18	36
February	-4.9	-1.0	-9.5	7.0	-18.6	11	9	5	4	13	7	28	23
March	-1.0	2.1	-4.2	8.8	-18.6	19	18	1	3	8	19	19	13
April	3.5	7.1	0.7	12.7	-3.4	14	15	3	8	13	12	11	25
May	9.3	13.6	5.9	25.7	-0.1	18	20	5	9	20	15	7	6
June	13.6	17.8	10.2	26.6	7.4	3	19	6	10	22	22	10	7
July	14.0	17.9	11.4	22.7	8.8	2	11	7	17	20	29	8	5
August	16.2	20.2	13.3	25.9	10.1	8	9	3	12	26	26	9	6
September	13.6	17.5	10.2	24.4	4.6	8	13	6	12	17	19	11	14
October	9.9	12.9	6.8	19.6	-1.2	4	8	3	9	22	22	18	13
November	5.3	8.0	2.2	13.1	-4.6	13	7	5	15	17	9	19	16
December	1.4	4.0	-1.8	12.2	-7.3	12	8	6	2	6	22	27	17
Annual	Mean 6.5	Mean 10.0	Mean 3.1	Extreme 26.6	Extreme -18.6	11	12	4	9	16	18	15	15
Years	1	1	1	1	1	1	1	1	1	1	1	1	1

*Each compass direction covers ±22.5 degrees

Table 4.37: Meteorological Data for Point Lepreau (average 1986 to 1991)

Month	Temperature (Degrees Celsius)					Wind Direction* Relative % % Observation From								Relative % Pasquill Stability Classes							% UNAV
	Avg	Mean Daily		Extreme																	
		Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F	G	
January	-4.9	-0.8	-8.9	7.2	-25.3	11	10	4	5	10	19	18	23	19	9	8	26	22	12	5	3
February	-5.4	-1.8	-9.4	7.3	-21.9	16	8	3	4	11	22	15	23	22	11	11	23	19	9	5	1
March	-1.5	1.5	-4.7	13.5	-24.9	19	13	4	5	15	17	9	19	16	8	8	25	25	12	7	2
April	3.3	5.9	1.1	16.4	-4.2	20	25	6	6	17	13	8	5	12	5	7	25	33	12	6	15
May	7.9	11.2	5.5	25.6	-0.7	13	19	6	6	22	22	7	5	8	4	6	21	32	17	13	18
June	11.4	14.6	9.0	26.1	4.1	8	17	7	6	20	23	12	8	4	2	3	16	36	23	16	14
July	14.4	17.3	12.0	25.2	6.9	5	12	5	7	25	31	10	6	2	1	2	11	31	27	27	9
August	14.8	17.5	12.7	25.0	8.3	6	10	5	8	23	27	14	8	2	1	1	9	29	33	26	7
September	12.0	14.4	9.9	26.3	1.1	8	9	4	6	20	24	16	14	5	2	3	18	34	25	13	6
October	8.4	10.7	6.1	18.9	-1.7	13	10	7	9	19	18	14	11	5	4	5	27	30	17	12	3
November	2.8	5.7	-0.2	14.5	-13.7	13	9	4	7	11	13	22	23	9	5	8	34	25	15	4	1
December	-4.0	-0.1	-8.0	11.1	-21.1	13	6	5	3	7	13	25	28	18	11	11	27	21	9	3	5
Period	Mean 4.9	Mean 8.1	Mean 2.2	Extreme 26.3	Extreme -25.3	12	12	5	6	17	20	14	15	10	5	6	22	28	18	11	7
Years	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

42 Metre Tower data
*Each compass direction covers ±22.5 degrees

Table 4.37: Meteorological Data for Point Lepreau (average 1986 to 1991)

Month	Temperature (Degrees Celsius)					Wind Direction* Relative % % Observation From								Relative % Pasquill Stability Classes							% UNAV
	Avg	Mean Daily		Extreme																	
		Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F	G	
January	-4.9	-0.8	-8.9	7.2	-25.3	11	10	4	5	10	19	18	23	19	9	8	26	22	12	5	3
February	-5.4	-1.8	-9.4	7.3	-21.9	16	8	3	4	11	22	15	23	22	11	11	23	19	9	5	1
March	-1.5	1.5	-4.7	13.5	-24.9	19	13	4	5	15	17	9	19	16	8	8	25	25	12	7	2
April	3.3	5.9	1.1	16.4	-4.2	20	25	6	6	17	13	8	5	12	5	7	25	33	12	6	15
May	7.9	11.2	5.5	25.6	-0.7	13	19	6	6	22	22	7	5	8	4	6	21	32	17	13	18
June	11.4	14.6	9.0	26.1	4.1	8	17	7	6	20	23	12	8	4	2	3	16	36	23	16	14
July	14.4	17.3	12.0	25.2	6.9	5	12	5	7	25	31	10	6	2	1	2	11	31	27	27	9
August	14.8	17.5	12.7	25.0	8.3	6	10	5	8	23	27	14	8	2	1	1	9	29	33	26	7
September	12.0	14.4	9.9	26.3	1.1	8	9	4	6	20	24	16	14	5	2	3	18	34	25	13	6
October	8.4	10.7	6.1	18.9	-1.7	13	10	7	9	19	18	14	11	5	4	5	27	30	17	12	3
November	2.8	5.7	-0.2	14.5	-13.7	13	9	4	7	11	13	22	23	9	5	8	34	25	15	4	1
December	-4.0	-0.1	-8.0	11.1	-21.1	13	6	5	3	7	13	25	28	18	11	11	27	21	9	3	5
Period	Mean 4.9	Mean 8.1	Mean 2.2	Extreme 26.3	Extreme -25.3	12	12	5	6	17	20	14	15	10	5	6	22	28	18	11	7
Years	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

42 Metre Tower data
*Each compass direction covers ±22.5 degrees

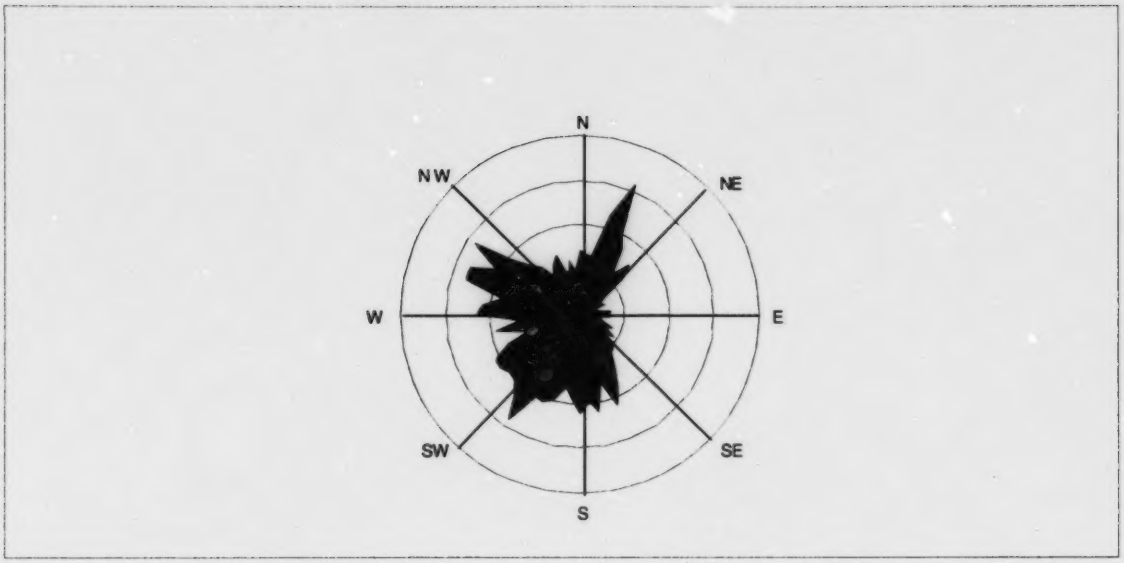

Figure 4.17: Wind Rose for Point Lepreau (2001)

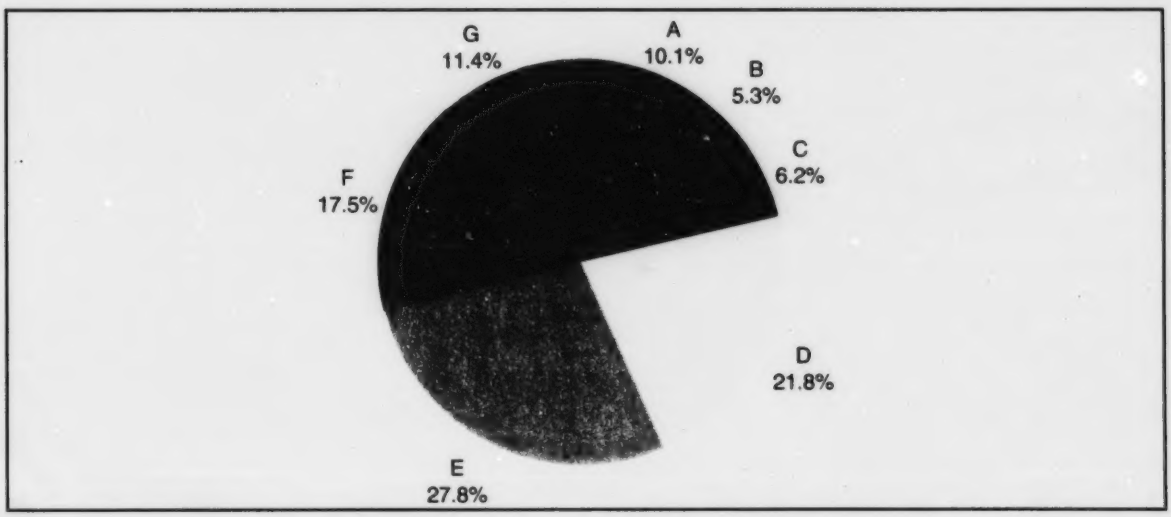

Figure 4.18: Pasquill Stability Factors for Point Lepreau (1986 to 1991)

5 Trends

The only trend that was obvious from the historical data, was increasing H-3 in Parshall Flume water from the SRWMF-Phase 1 (Figure 5.20). However, this trend did not continue into 2001.

As in the figures in Section 4, "Less Than" values are plotted for non-detected values. All location codes are described in Appendix C.

5.01 Dose from Airborne and Liquid Pathways

Radiation dose from PLGS emissions continues to be well below the public dose limit (1000 microsieverts per annum), and also well below the operating target for nuclear power facilities in Canada (50 microsieverts per annum). See Figure 5.01.

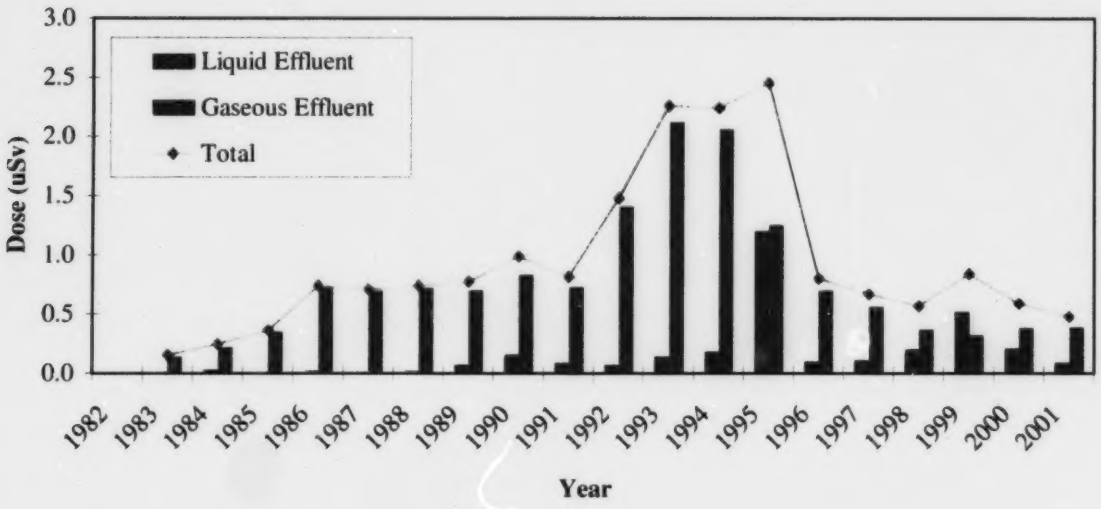

Figure 5.01: Dose from Airborne and Liquid Pathways

5.02 Gross Beta in Air

Figures 5.02 and 5.03 show the gross beta data for all air stations since the NB Power program began in 1976. A plot of the gross beta data from Dipper Harbour, about 4 km from the PLGS stack and in the predominant downwind direction, is presented in Figure 5.04. The baseline data show the naturally occurring radioactivity in the area. The peaks on the plots correspond to fallout from various atmospheric bomb tests that were most common in the 1950s and 1960s but decreased into the 1970s. Fallout from the Chinese atmospheric bomb test in October of 1980 (fallout occurred in 1981 in N.B.), and from the Chernobyl accident in April 1986, were obvious. Figure 5.05 shows a comparable plot of data from Health and Welfare Canada, but for the whole of Canada from 1959 (when data were first collected) to 1991. The scale is very much condensed to allow the bomb test fallout levels to be kept on-scale.

The Chernobyl accident released, in a period of a few days, about 1% as much radioactivity to the environment as all of the U.S. atmospheric bomb tests combined, released over several years.

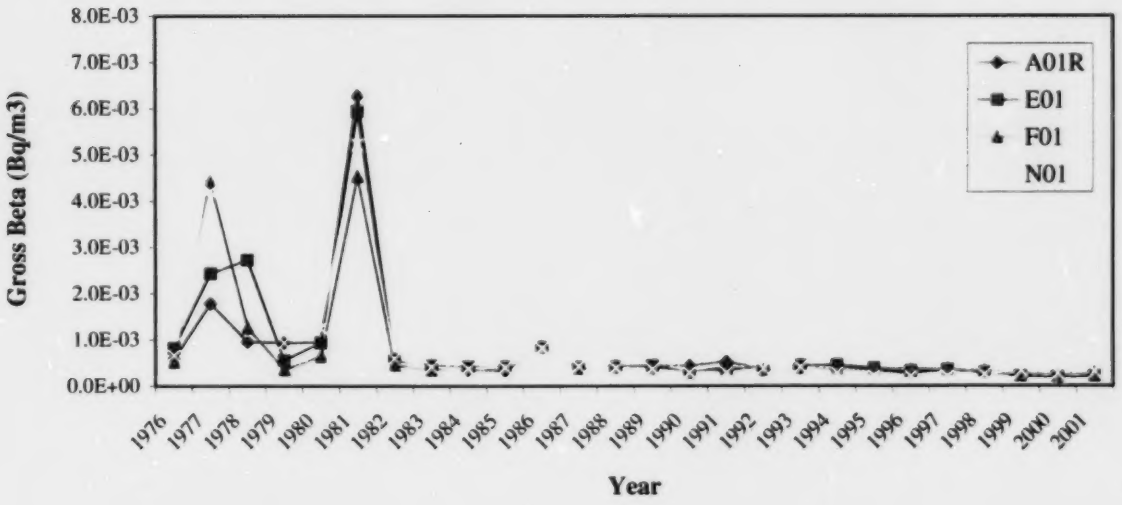

Figure 5.02: Gross Beta in Air (Offsite Air Stations)

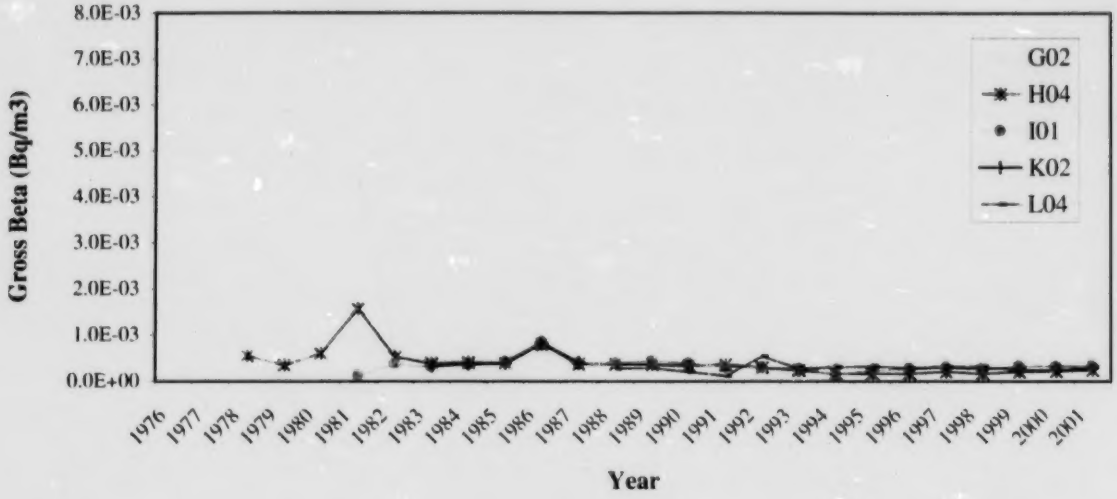

Figure 5.03: Gross Beta in Air (Onsite Air Stations)

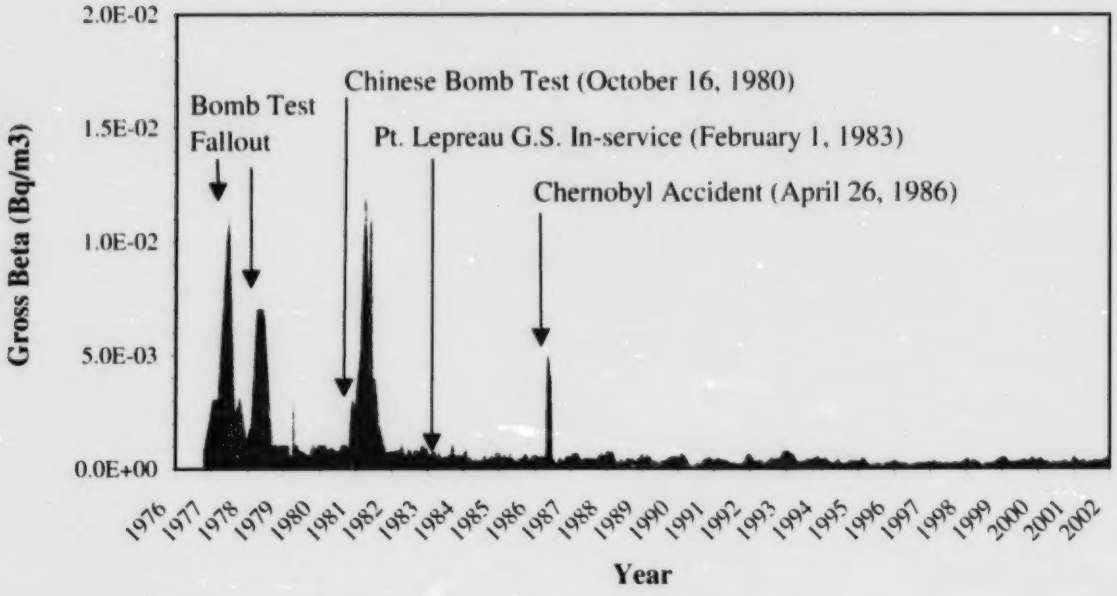

Figure 5.04: Gross Beta Activity in Air at Dipper Harbour

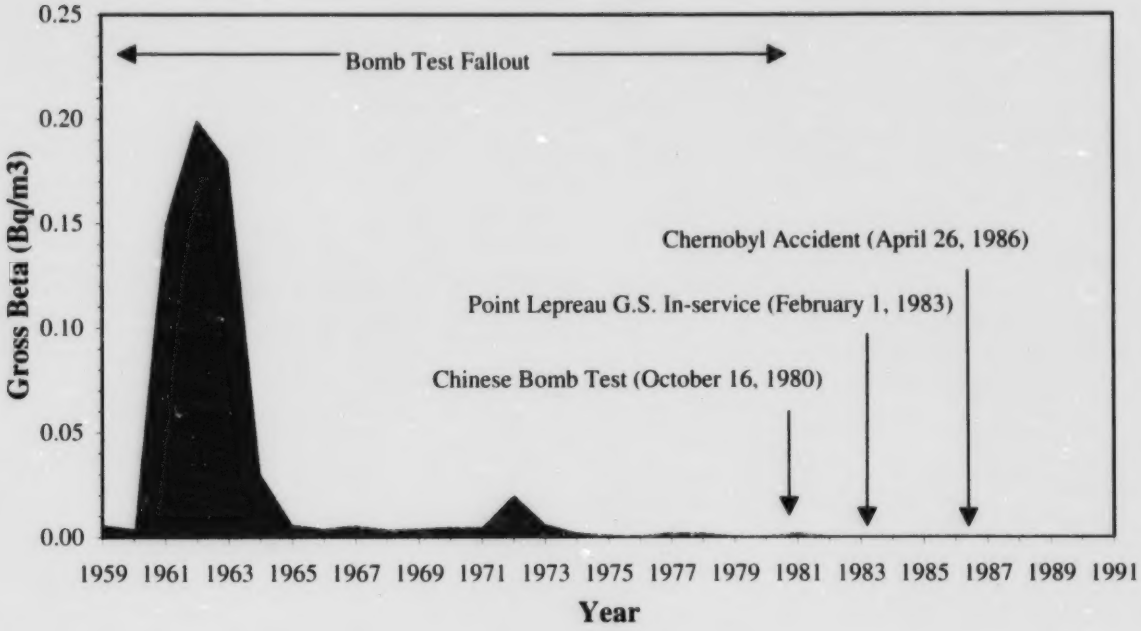

Figure 5.05: Annual Average Gross Beta Activity in Air for Canada 1959 to 1991 (Health and Welfare Canada Data)

5.03 Tritiated Water in Air

The onsite stations show a decline since the peak in 1993/1994, as have station airborne tritium emissions. See Figures 5.06 and 5.07.

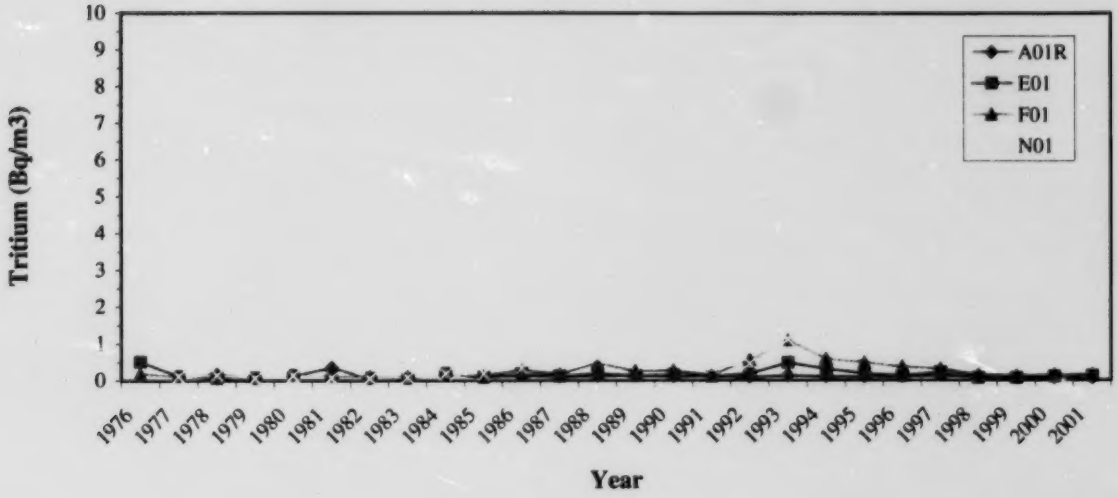

Figure 5.06: Tritiated Water in Air (Offsite)

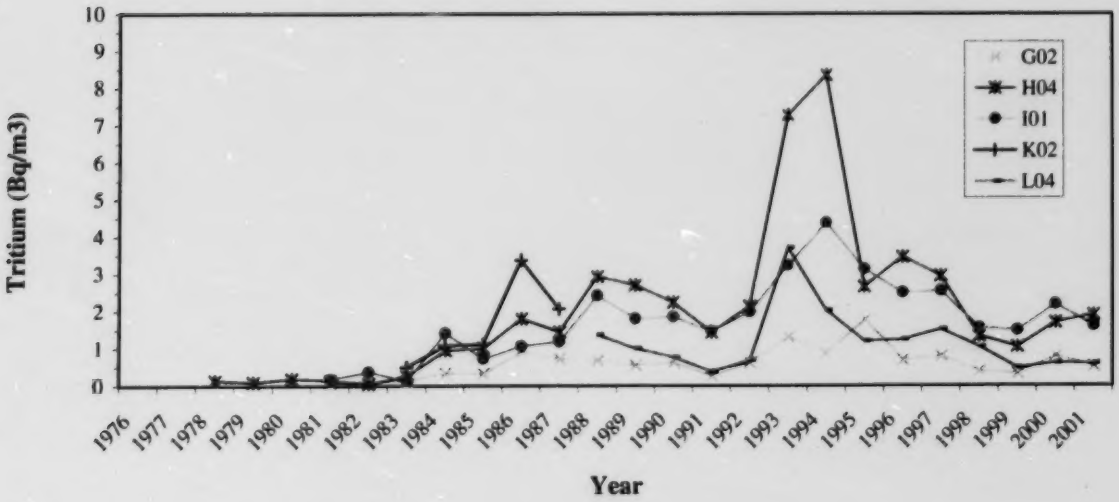

Figure 5.07: Tritiated Water in Air (Onsite)

5.04 Atmospheric Dispersion Factors

The annual average dispersion factor for stack emissions up to this time is between 1E-7 and 2E-7 s/m^3. This factor is based upon the data for H-3. A value of 2E-7, based on such empirical data, is used in the DEL calculations. Results since 1984 are presented in Table 5.02.

In the calculation of the mean dispersion factor at each location, the average recorded is now the average of the detected values and the "Less Than" values. This will give a conservative estimate of the true value (i.e., less dispersion of the radionuclides).

To derive a normalised mean dispersion factor at 1 km from the stack for all locations, each dispersion factor value is corrected to 1 km. This is accomplished by tracing back between dispersion curves on the graph of "Weighted Mean Dilution Factor versus Distance from the Point of Continuous Emission"[9]. The average of these normalised values is presented in Table 5.01.

Table 5.01: Normalised Mean Dispersion Factor at 1 km for All Indicator Locations

Year	*Dispersion Factor (s/m^3)*
1984	2E-07
1985	1E-07
1986	1E-07
1987	1E-07
1988	2E-07
1989	2E-07
1990	1E-07
1991	1E-07
1992	1E-07
1993	1E-07
1994	1E-07
1995	2E-07
1996	2E-07
1997	2E-07
1998	2E-07
1999	2E-07
2000	2E-07
2001	2E-07
Average over 18 years	<2E-07

5.04 Atmospheric Dispersion Factors

The annual average dispersion factor for stack emissions up to this time is between 1E-7 and 2E-7 s/m^3. This factor is based upon the data for H-3. A value of 2E-7, based on such empirical data, is used in the DEL calculations. Results since 1984 are presented in Table 5.02.

In the calculation of the mean dispersion factor at each location, the average recorded is now the average of the detected values and the "Less Than" values. This will give a conservative estimate of the true value (i.e., less dispersion of the radionuclides).

To derive a normalised mean dispersion factor at 1 km from the stack for all locations, each dispersion factor value is corrected to 1 km. This is accomplished by tracing back between dispersion curves on the graph of "Weighted Mean Dilution Factor versus Distance from the Point of Continuous Emission"[9]. The average of these normalised values is presented in Table 5.01.

Table 5.01: Normalised Mean Dispersion Factor at 1 km for All Indicator Locations

Year	*Dispersion Factor (s/m^3)*
1984	2E-07
1985	1E-07
1986	1E-07
1987	1E-07
1988	2E-07
1989	2E-07
1990	1E-07
1991	1E-07
1992	1E-07
1993	1E-07
1994	1E-07
1995	2E-07
1996	2E-07
1997	2E-07
1998	2E-07
1999	2E-07
2000	2E-07
2001	2E-07
Average over 18 years	<2E-07

Table 5.02: Average Atmospheric Dispersion Factor for Each Air Monitoring Location

Location Code		*E01*	*F01*	*G02*	*H04*	*I01*	*K02*	*L04*	*N01*
Location		*Maces Bay*	*Welch Cove*	*Lepreau Lighthouse*	*Old Site of Information Centre*	*SRWMF*	*CCW Pumphouse*	*Construction Stores*	*Dipper Harbour*
Distance from PLGS		*4.5 km*	*1.6 km*	*1.0 km*	*0.75 km*	*1.2 km*	*0.2 km*	*0.55 km*	*3.7 km*
Year	*Release (Bq)*	*Dispersion Factor (s/m^3)*							
1984	6.8E13	8E-8	8E-8	2E-7	5E-7	7E-7**	5E-7	-	8E-8
1985	1.1E14	2E-8	4E-8	9E-8	3E-7	2E-7	3E-7	-	5E-8
1986	2.0E14	3E-8	5E-8	1E-7	3E-7	2E-7	5E-7	-	6E-8
1987	2.2E14	2E-8	2E-8	1E-7	2E-7	2E-7	3E-7	-	7E-8
1988	2.2E14	3E-8	7E-8	1E-7	4E-7	3E-7	#	2E-7	9E-8
1989	2.1E14	2E-8	4E-8	8E-8	4E-7	3E-7	#	2E-7	8E-8
1990	2.5E14	2E-8	3E-8	8E-8	3E-7	2E-7	#	1E-7	8E-8
1991	1.7E14	2E-8	3E-8	5E-8	3E-7	3E-7	#	7E-8	7E-8
1992	3.6E14	2E-8	5E-8	5E-8	2E-7	2E-7	#	6E-8	4E-8
1993	6.4E14	2E-8	5E-8	6E-8	4E-7	2E-7	#	2E-7	5E-8
1994	5.6E14	2E-8	3E-8	5E-8	5E-7	2E-7	#	1E-7	1E-7
1995	3.1E14	2E-8	5E-8	2E-7	3E-7	3E-7	#	1E-7	4E-8
1996	2.4E14	2E-8	5E-8	9E-8	5E-7	3E-7	#	2E-7	8E-8
1997	2.1E14	3E-8	5E-8	1E-7	4E-7	4E-7	#	2E-7	9E-8
1998	1.3E14	2E-8	3E-8	1E-7	3E-7	4E-7	#	3E-7	5E-8
1999	9.5E13	7E-8	5E-8	1E-7	3E-7	5E-7	#	1E-7	1E-7
2000	1.3E14	2E-8	3E-8	2E-7	4E-7	5E-7	#	1E-7	8E-8
2001	1.3E14	9E-8	5E-8	1E-7	4E-7	4E-7	#	1E-7	2E-7

**This value includes a second source term: H-3 from containers temporarily located in this facility in 1984 and picked up by the air sampler (ignored in the calculation of the normalised mean dispersion factor).

No longer in use. This monitoring station was relocated to L04 - the Construction Stores Compound - in the spring of 1988.

Table 5.02: Average Atmospheric Dispersion Factor for Each Air Monitoring Location

Location Code		*E01*	*F01*	*G02*	*H04*	*I01*	*K02*	*L04*	*N01*
Location		*Maces Bay*	*Welch Cove*	*Lepreau Lighthouse*	*Old Site of Information Centre*	*SRWMF*	*CCW Pumphouse*	*Construction Stores*	*Dipper Harbour*
Distance from PLGS		*4.5 km*	*1.6 km*	*1.0 km*	*0.75 km*	*1.2 km*	*0.2 km*	*0.55 km*	*3.7 km*
Year	*Release (Bq)*	*Dispersion Factor (s/m^3)*							
1984	6.8E13	8E-8	8E-8	2E-7	5E-7	7E-7**	5E-7	-	8E-8
1985	1.1E14	2E-8	4E-8	9E-8	3E-7	2E-7	3E-7	-	5E-8
1986	2.0E14	3E-8	5E-8	1E-7	3E-7	2E-7	5E-7	-	6E-8
1987	2.2E14	2E-8	2E-8	1E-7	2E-7	2E-7	3E-7	-	7E-8
1988	2.2E14	3E-8	7E-8	1E-7	4E-7	3E-7	#	2E-7	9E-8
1989	2.1E14	2E-8	4E-8	8E-8	4E-7	3E-7	#	2E-7	8E-8
1990	2.5E14	2E-8	3E-8	8E-8	3E-7	2E-7	#	1E-7	8E-8
1991	1.7E14	2E-8	3E-8	5E-8	3E-7	3E-7	#	7E-8	7E-8
1992	3.6E14	2E-8	5E-8	5E-8	2E-7	2E-7	#	6E-8	4E-8
1993	6.4E14	2E-8	5E-8	6E-8	4E-7	2E-7	#	2E-7	5E-8
1994	5.6E14	2E-8	3E-8	5E-8	5E-7	2E-7	#	1E-7	1E-7
1995	3.1E14	2E-8	5E-8	2E-7	3E-7	3E-7	#	1E-7	4E-8
1996	2.4E14	2E-8	5E-8	9E-8	5E-7	3E-7	#	2E-7	8E-8
1997	2.1E14	3E-8	5E-8	1E-7	4E-7	4E-7	#	2E-7	9E-8
1998	1.3E14	2E-8	3E-8	1E-7	3E-7	4E-7	#	3E-7	5E-8
1999	9.5E13	7E-8	5E-8	1E-7	3E-7	5E-7	#	1E-7	1E-7
2000	1.3E14	2E-8	3E-8	2E-7	4E-7	5E-7	#	1E-7	8E-8
2001	1.3E14	9E-8	5E-8	1E-7	4E-7	4E-7	#	1E-7	2E-7

**This value includes a second source term: H-3 from containers temporarily located in this facility in 1984 and picked up by the air sampler (ignored in the calculation of the normalised mean dispersion factor).

No longer in use. This monitoring station was relocated to L04 - the Construction Stores Compound - in the spring of 1988.

5.05 Strontium-90 in Air (GEM)

There have only been a few years when Sr-90 was detected in station effluents. The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit.

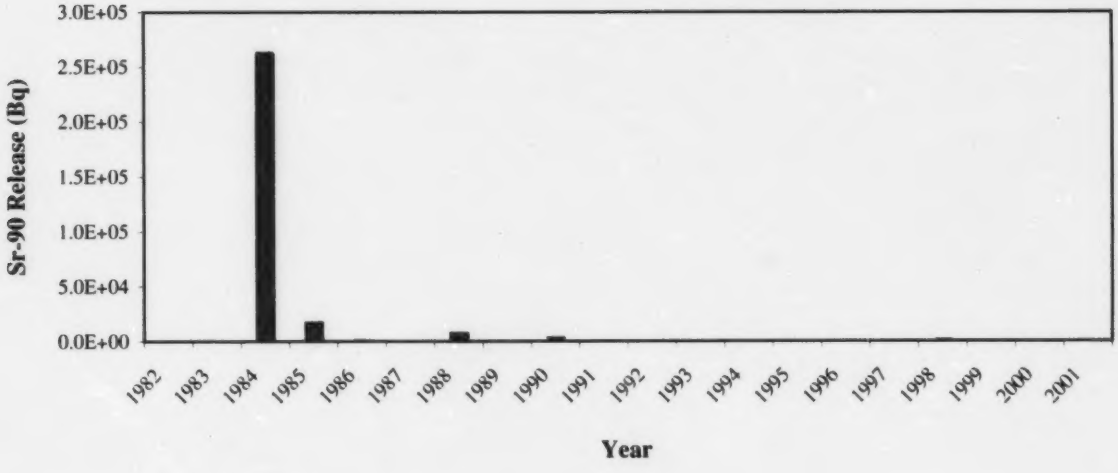

Figure 5.08: Sr-90 in Air (GEM)

5.06 TLD Measurements

A plot of summary TLD data since 1978 is presented in Figure 5.09. There is only one reference location (A01R in Bocabec) while the other groups are the average of many locations. *Boundary* refers to locations at the edge of NB Power property.

The variation in natural background radiation at any individual location covers a range of about 300 microgray from year to year. A few locations (close to the reactor building and the air emissions stack) show significant, but small, increases in gamma radiation due to chronic releases of low levels of noble gases. In 1995, the extended outage resulted in fewer noble gas emissions and thus lower dose measured by these TLDs. Small increases at the SRWMF are due to low-level waste and used fuel emplacement and not to station emissions.

Background radiation in any of the monitored residential areas has not increased from the levels measured before the Point Lepreau Generating Station was placed into operation.

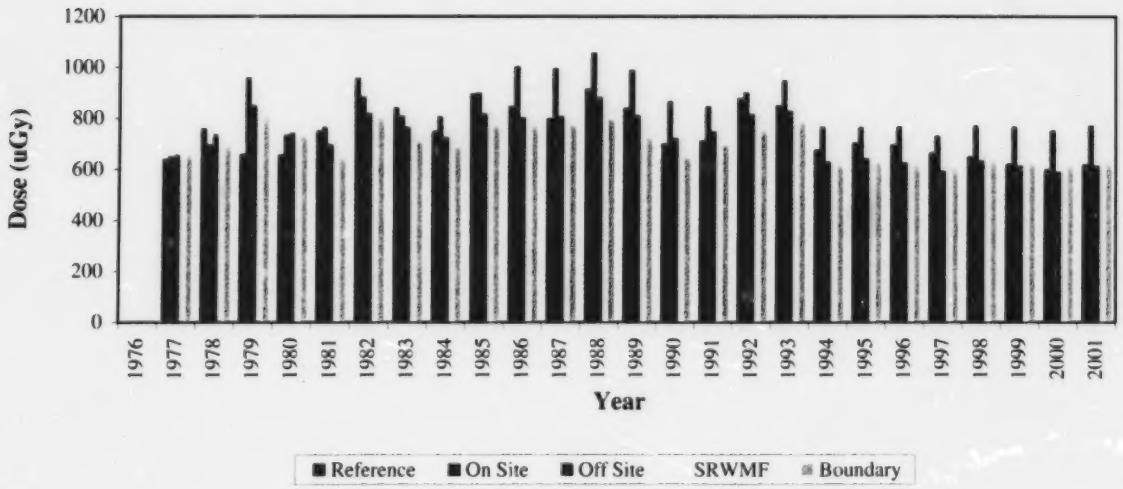

Figure 5.09: TLD Measurements

5.07 Gross Beta in Well Water

The beta activity is due to the presence of naturally occurring radionuclides (especially radon progeny). As expected, there has been no significant change in this parameter over the years.

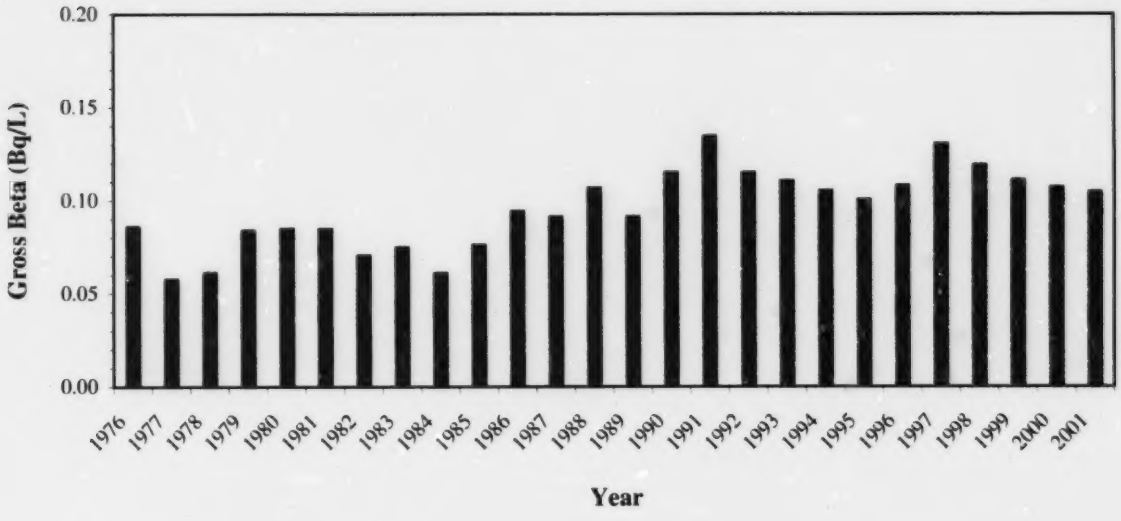

Figure 5.10: Gross Beta in Well Water

5.08 Tritium in Well Water

Precipitation and surface water contain tritium from PLGS emissions. Even though there is surface runoff into some shallow wells, there has been no significant change in this parameter over the years.

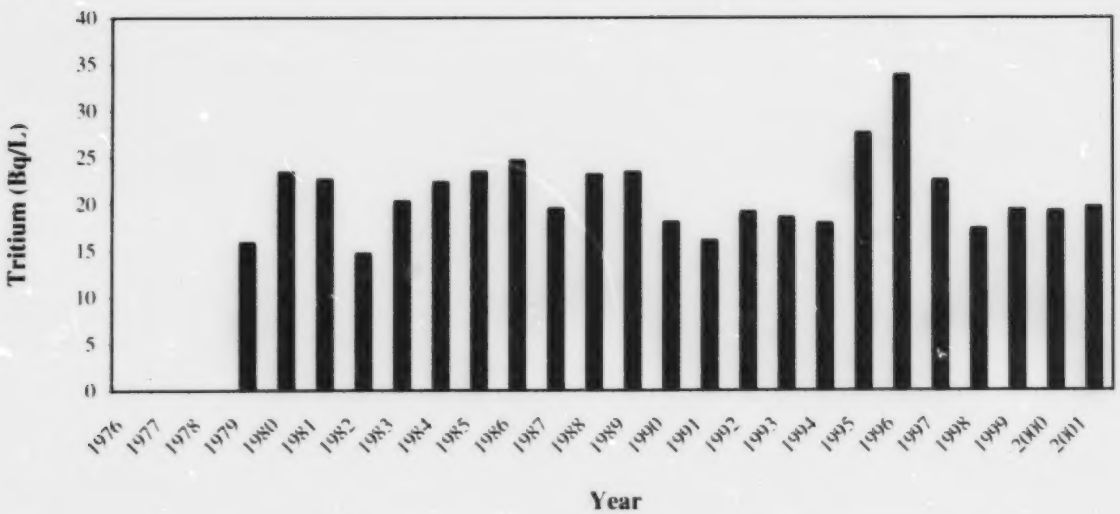

Figure 5.11: Tritium in Well Water

5.09 Cs-137 in Soil

Cesium-137 from fallout from past atmospheric bomb tests tends to accumulate in the organic layer of the soil. Any fluctuation seems to be due to this organic load in the sample. There were no soil samples from 1986 to 1992 because at the time, this fluctuation caused it to be viewed as an unimportant sample type.

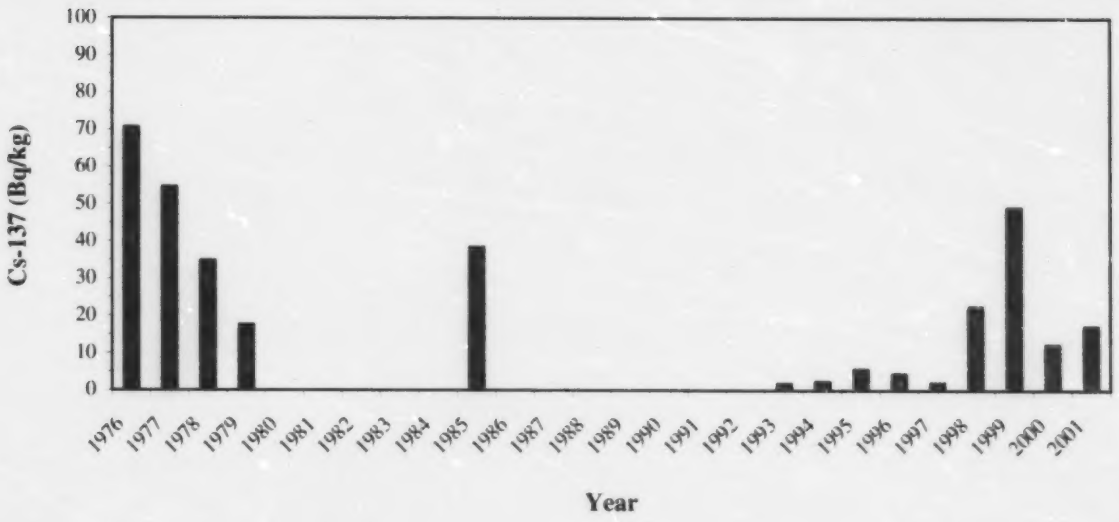

Figure 5.12: Cs-137 in Soil

5.10 Cs-137 in Sediment

The effects of the atmospheric bomb tests and the accident at Chernobyl continue to be seen here. There has been no significant change in this parameter over the years.

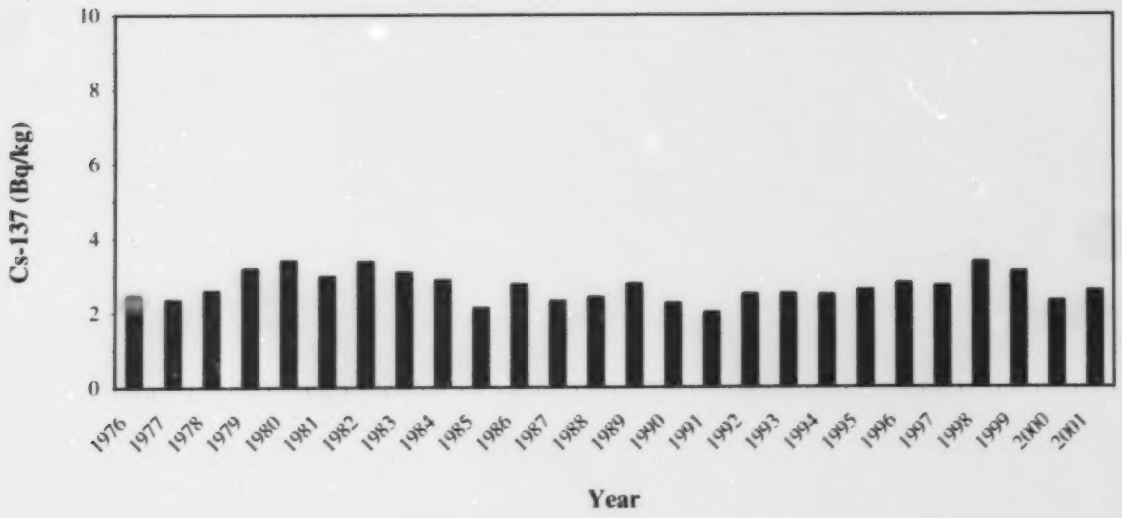

Figure 5.13: Cs-137 in Sediment

5.11 Tritium in Seawater

The increase in H-3 in 1996 and 1997 were due to samples being taken directly over the out-fall. These samples are usually taken at the shore, where the effects of tidal mixing are evident.

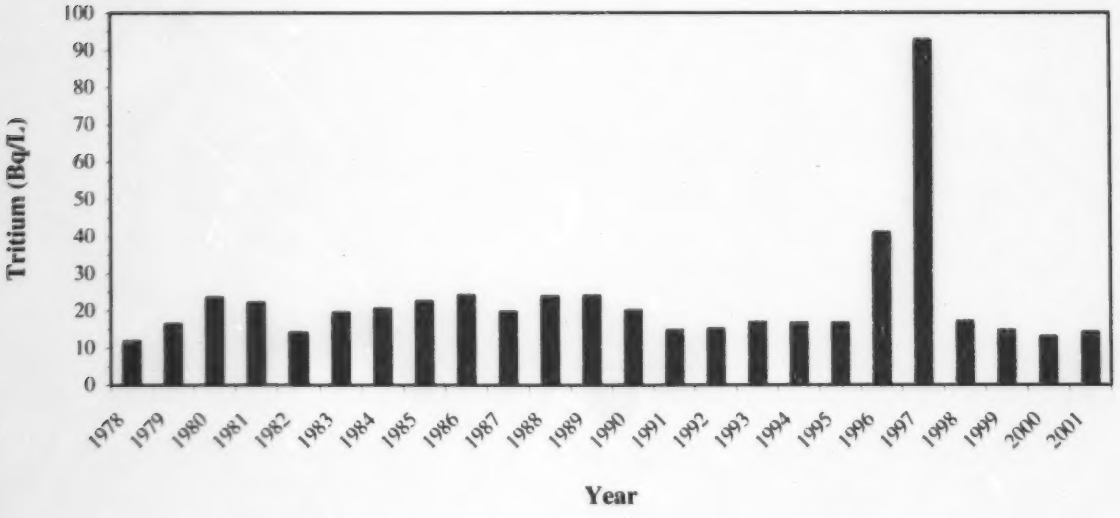

Figure 5.14: Tritium in Seawater

5.12 Strontium-90 in LEM

The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit.

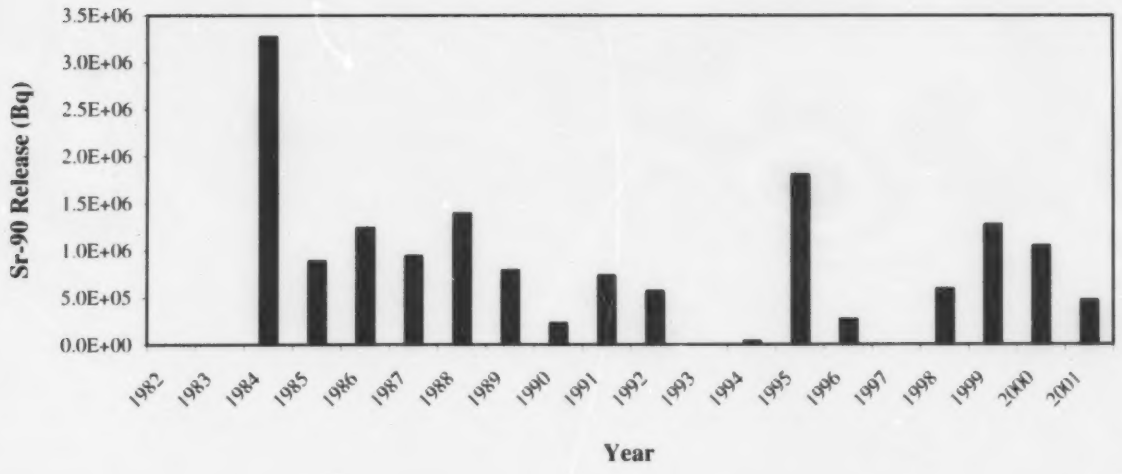

Figure 5.15: Sr-90 in LEM

5.13 Tritium in Bore Holes and Parshall Flumes

The values at Phase 2 are typically less than those at Phase 1, indicating possible dilution of the surface runoff to the flume or a developing problem with the Phase 1 structures. There has been a general upward trend in the Phase 1 Parshall Flume and bore hole results since the late 1980s. That trend was reversed in 2001.

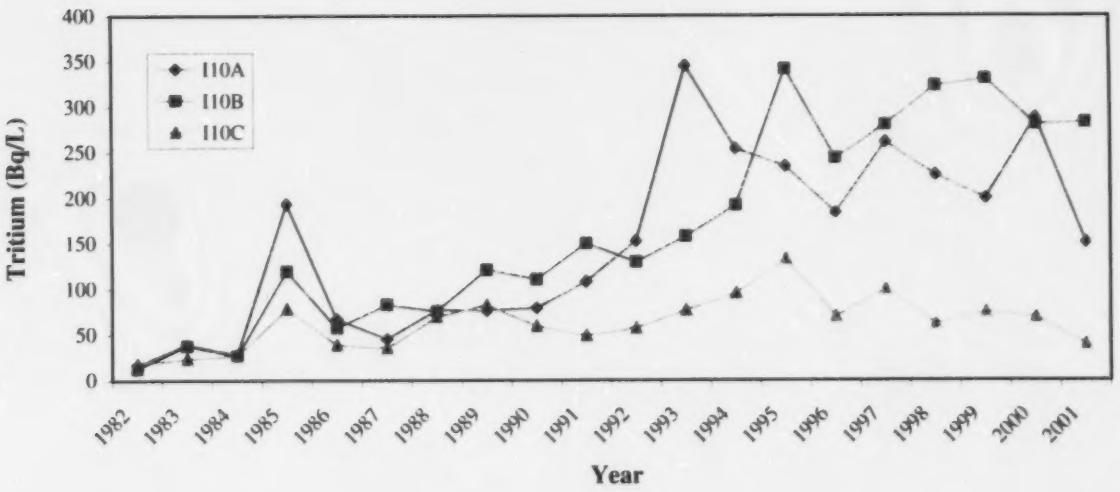

Figure 5.16: H-3 in Bore Holes

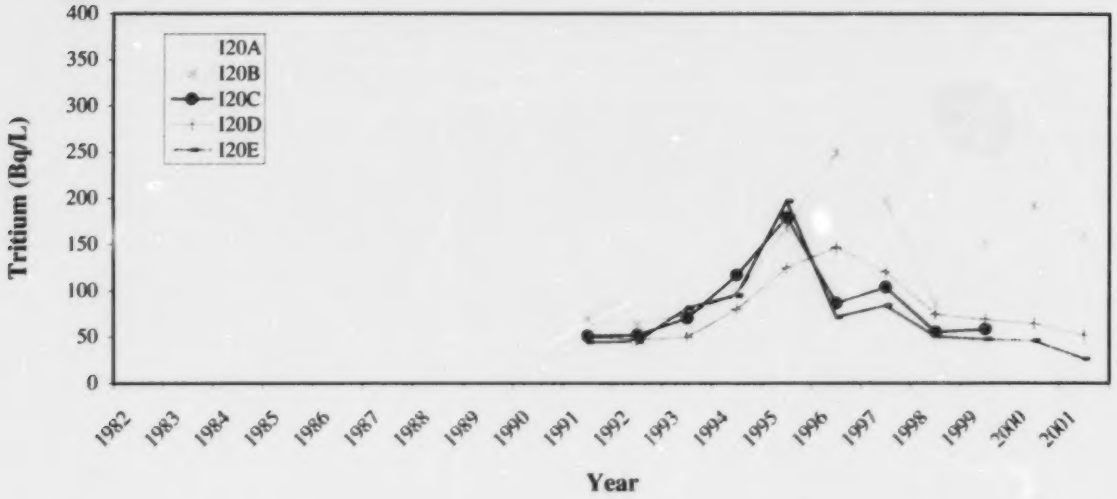

Figure 5.17: H-3 in Bore Holes

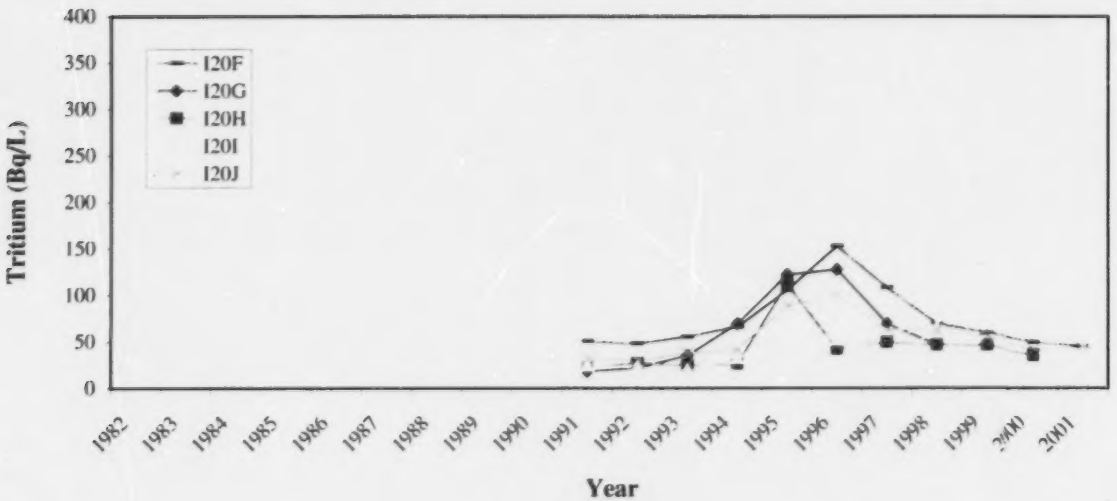

Figure 5.18: H-3 in Bore Holes

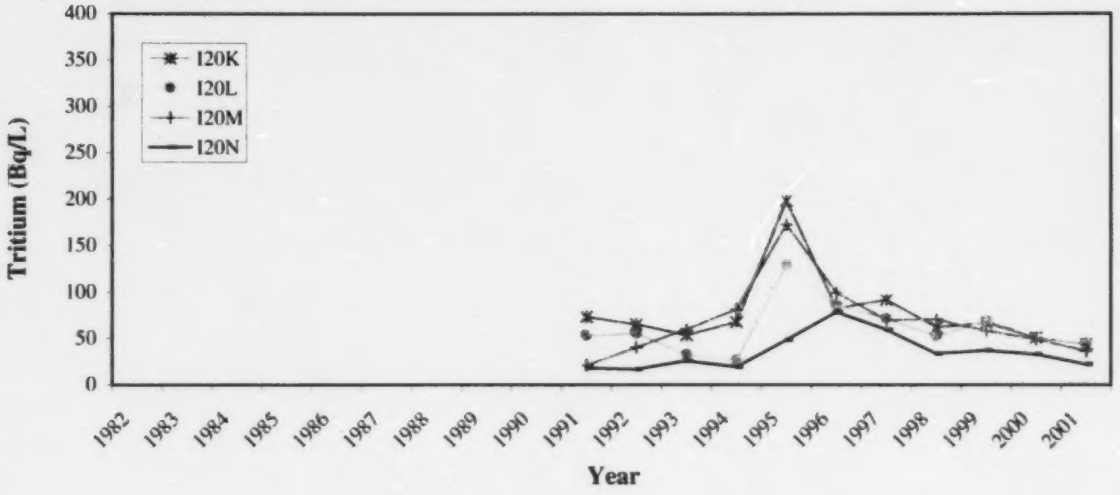

Figure 5.19: H-3 in Bore Holes

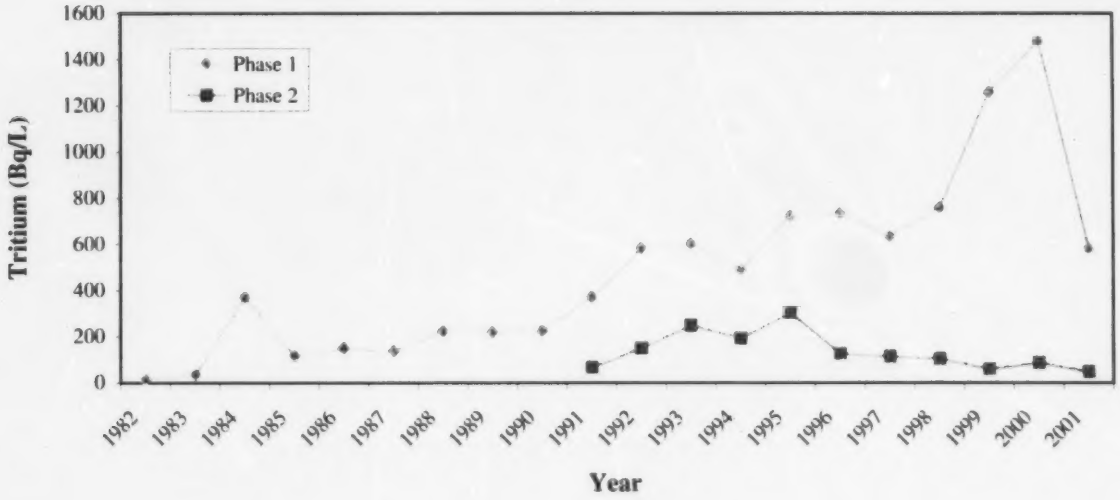

Figure 5.20: H-3 in Parshall Flumes

5.14 Drop-off TLDs

Dosimeters are in place in two directions from the boundary fence of the SRWMF - Phase 2 facility to measure drop-off of radiation from the filled dry fuel storage canisters with distance, to about 200 metres. Results are presented in Figure 5.21. Each point on the graph is the average for all the years the facility has operated. The B direction is higher than the A direction because the rocky terrain has a higher natural background.

The bar charts in Figure 5.22 and Figure 5.23 present the annual dose for each location (since 1991).

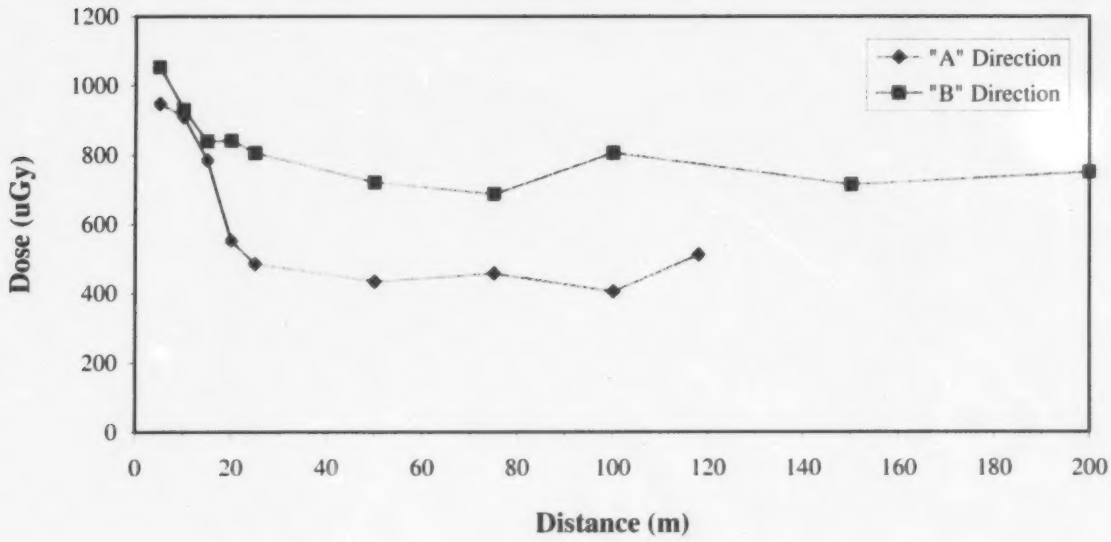

Figure 5.21: Drop-off TLDs

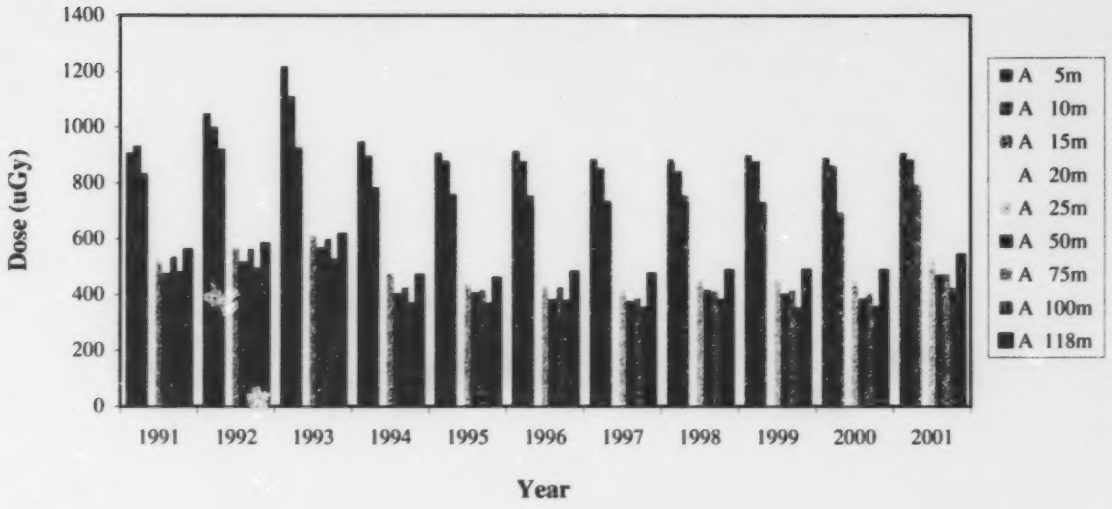

Figure 5.22: Drop-off TLDs

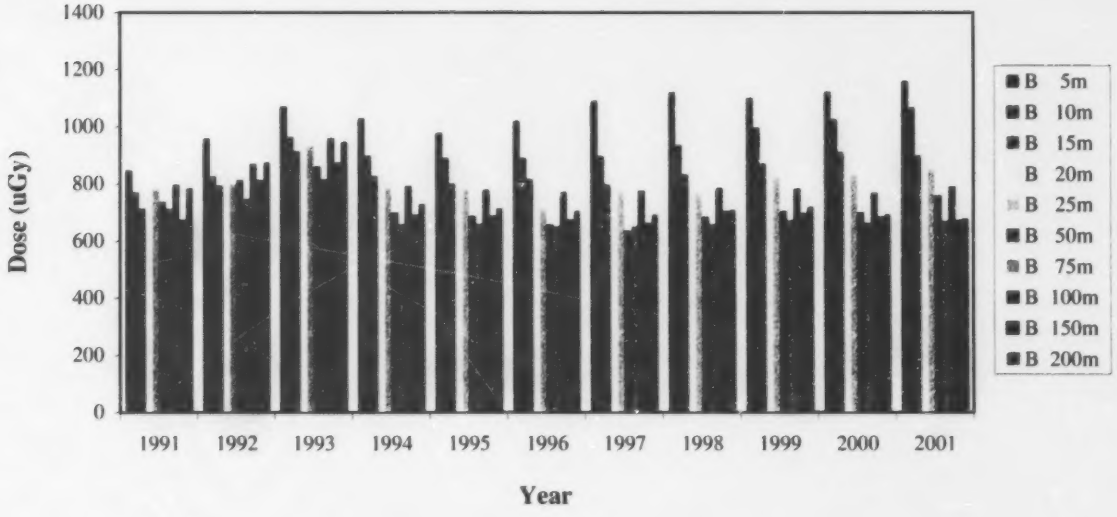

Figure 5.23: Drop-off TLDs

6 Dose Estimation

Based upon the total percent DEL for all monitored radionuclides in each pathway for 2001, the calculated annual whole body radiation dose to members of the Critical Groups was about 0.1 μSv from liquid emissions and about 0.4 μSv from airborne emissions. This latter calculation allows for the actual location of an existing dairy herd in 2001 at about 40 km, rather than assuming the existence of a hypothetical herd at 1.5 km. This results in a dose reduction factor of about 12 for C-14 in the milk pathway because of the differences in dispersion factors between 1.5 km and 40 km (6E-08 s/m^3, and 5E-09 s/m^3, respectively).

Because of the protective assumptions used in the DEL calculations, and the relatively low level of emissions, the most exposed member of the general public received far less than the calculated dose. This radiation dose may be compared with the individual natural radiation dose in the Point Lepreau area of approximately 2000 to 3000 μSv per annum. (TLDs show only the external, penetrating component, amounting to about 500 to 1000 μSv.) This includes natural dose contributions from ground, air, food and from an assumed low concentration of radon in homes. A significant fraction of Canadian homes contain radon levels that give a radiation dose much larger than this. In addition, the average annual medical radiation dose is about 350 μSv per person.

Table 6.01: Annual Dose

Source of Dose to Critical Group	*Dose to Critical Group (μSv/a)*
PLGS airborne emissions	0.39
PLGS liquid emissions	0.09
natural background (estimate)	2 000
average medical dose (estimate)	350

The only assessable radiation dose from PLGS to the local population is that from tritiated water vapour in air. This continues to be detected offsite in air and water samples.

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7 Quality Assurance Results

The purpose of Quality Assurance is to provide confidence in the program and demonstrate that the program is able to meet its objectives. QA consists of the system whereby the laboratory can assure the regulator, NB Power, and the public that the laboratory is generating data of proven and known quality. It encompasses:

- personnel
- procedures
- measurements
- contamination
- records
- annual review
- program audits
- program improvement

This section describes how this was achieved for the year 2001. The specific procedures can be found in the *Quality Assurance* section of *Environmental Radiation Monitoring Program Procedures*[11].

7.01 Daily Quality Control

At the beginning of each day, the four main pieces of analytical equipment have a quality control check performed on them. Key instrument parameters are checked and the results are compared against tolerance limits, and are also compared with previous results to detect trends in performance. To perform the quality control checks, radiation sources traceable to US or Canadian standards (National Institute of Standards and Technology and National Research Council) are used. Failures are investigated immediately.

The daily Quality Control (QC) evaluations in the laboratory cover the following instruments:

1. Canberra Intrinsic Ge Gamma Spectrometer
2. Beckman Liquid Scintillation Counter
3. Tennelec LB-5100 Gross Alpha/Beta Detector
4. Panasonic UD-710A TLD Reader

In the QC program, the operating parameters of each of the major instruments are evaluated at the start of each working day. This ensures that they are consistent and remain free from significant drift or random variation that could influence the analyses. A compilation of the results and statistical fluctuations is maintained, and from these data the upper and lower flag limits are determined. If any equipment exceeds these limits, it is not used for any analytical work until the problem has been resolved.

Throughout the year there were failures for each of the instruments. These failures involved only one of the seven to ten parameters monitored for each system. All of these failures were minor and were resolved on the same day they occurred.

Table 7.01: Daily QC Passes & Failures

Instrument	*Number of Parameters Monitored*	*Runs*	*Runs Passed*	*Parameters Failed*	*Unresolved Failures*
Canberra Intrinsic Ge Gamma Spectrometer	7	249	248	2	0
Canberra Intrinsic Ge Gamma Spectrometer (Weekend Long Background)	8	51	50	4	0
Beckman Liquid Scintillation Counter	10	248	242	8	0
Tennelec LB-5100 Gross Alpha/Beta Detector	8	248	239	12	0
Panasonic UD-710A TLD Reader	8	248	243	5	0

7.01.01 Intrinsic Ge Gamma Spectrometer

A daily check of seven system parameters is performed for the germanium gamma spectroscopy system. Measurements are made of the energy centroids, full width half maxima (FWHM) and efficiencies of two widely separated photon energies of Eu-152. These show the accuracy and precision of the system relative to the defined limits of acceptance. The rate of liquid nitrogen consumption is monitored to verify the physical integrity of the cryostat. A computer program that generates QC plots and performs statistical tests to detect out-of-range values processes the results. A 200 000 s background count is made each weekend to ensure the absence of contamination in the sample chamber. The QC program evaluates the total counts in eight separate regions of the background spectrum, and out-of-range values are flagged for assessment.

The efficiency calibration of the gamma spectroscopy system is checked annually for each of the counting geometries. This is accomplished using a mixed nuclide standard traceable to the U.S. National Institute of Standards and Technology (NIST).

7.01.02 Beckman Liquid Scintillation Counter (model LS 6000TA)

A set of sealed tritium, C-14 and background standards traceable to NIST is analysed daily. Statistical parameters must lie within defined limits or the equipment will not be used. These same standards are used to calibrate the instrument for each analysis run.

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7.01.03 Tennelec LB-5100 Gross Alpha/Beta Detector

Planchet standards of Am-241 and Sr,Y-90 are analysed daily. Alpha and Beta discrimination allows the simultaneous analysis of alpha and beta emissions on all samples analysed. Planchet and filter backgrounds are included in the QC checks. These same standards are used to calibrate the instrument for each analysis run.

7.01.04 Panasonic UD-710A TLD Reader

A set of 16 TLDs is exposed in the Panarad Irradiator and read out in the TLD reader. The mean of each of the four elements, dark current, reference light, reference element, and lamp flashes must all be within specified limits. The QA aspect of this system is covered in detail in *External Beta/Gamma Dosimetry Program*[10].

7.01.05 Other Instruments

Other instruments (balances, pipettes) are checked or calibrated at least annually. See the *Calibration, Maintenance and Repair* section of *Environmental Radiation Monitoring Program Procedures*[11]. Frequencies of calibration are based on reproducibility of measurements and on time stability tests to ensure that the measurements made are within the specified tolerances for accuracy.

The gamma survey meters and contamination monitor are calibrated at PLGS on an annual basis.

7.02 External QA

The external quality assurance program consists of inter-comparisons with other laboratories, to give independent verification of analytical performance. The frequency of each program may vary at the discretion of the sponsoring agency (see Table 7.02). Three such groups – the IAEA (International Atomic Energy Agency), USDOE (United States Department of Energy), and NTS (Nuclear Technology Services) provide up to 5% of the sample load in the laboratory with blind or semi-blind samples. Results of our performance with these samples give an indication of the quality of measurements we are capable of producing.

This laboratory experienced numerous problems with its major supplier of QA samples in 2001. By the end of the year, it was decided to switch to a more dependable company.

The results are tabulated in Tables 7.03 to 7.16 and presented graphically in Figures 7.01 to 7.19. The tables show the sample date, while the figures show the analysis date.

The QA agent defines acceptable performance, generally in terms of an expected range. A failure signals the need to assess the procedures, analytical methods, or equipment calibrations.

There were 22 failures (out of 207 tests) in the external QA program in 2001:

- Alpha on Air Filter (NTS) – There were three failures due to geometry differences between the calibration standard and QA samples (see Table 7.04).
- C-14 in Water (NTS) – Investigation of the one failure cast suspicion on the QA sample supplier (see Table 7.06).
- Sr-89 in Water (NTS) - Investigation of the one failure cast suspicion on the QA sample supplier (see Table 7.06).
- Gamma Emitters in Charcoal Cartridge (NTS) – All seven failures were in one charcoal cartridge. The QA supplier had deviated from the specified method of sample preparation (see Table 7.07).
- Sr-90 in Water (USDOE) – Lab personnel did not apply a yield factor to the results (see Table 7.08).
- Gamma Emitters in IAEA Solid Samples – There were nine failures. These samples were made up by the IAEA as early as 1983. Their pass criteria are extremely tight (as low as ±1.8%) and do not allow for the geometry effects of these small, powdered samples (see Tables 7.13, 7.14 and 7.15).

Table 7.02: External Quality Assurance Frequency

Media	*Analyses*	*Number of QA Samples in 2001*	*External Agencies*
Filters	Gross Alpha/Beta	2	USDOE
		4	NTS
	Gamma	2	USDOE
		4	NTS
	Sr-89,90	2	USDOE
		4	NTS
Environmental Gamma	TLD	2	NRC
		no test in 2001	USDOE
Milk	Gamma	1	IAEA
Soil/Sediment	Gamma	2	USDOE
		2	IAEA
Water	Gross Alpha/Beta	2	USDOE
		4	NTS
	H-3	2	USDOE
		4	NTS
	C-14	4	NTS
	Gamma	2	USDOE
		4	NTS
	Sr-89,90	2	USDOE
		4	NTS
Charcoal Cartridges	Gamma	4	NTS
Food	Gamma	2	USDOE
		4	NTS
		2	IAEA
Urine	H-3	3	RPB
	C-14	3	RPB
	Gamma	1	RPB

Table 7.02: External Quality Assurance Frequency

Media	*Analyses*	*Number of QA Samples in 2001*	*External Agencies*
Filters	Gross Alpha/Beta	2	USDOE
		4	NTS
	Gamma	2	USDOE
		4	NTS
	Sr-89,90	2	USDOE
		4	NTS
Environmental Gamma	TLD	2	NRC
		no test in 2001	USDOE
Milk	Gamma	1	IAEA
Soil/Sediment	Gamma	2	USDOE
		2	IAEA
Water	Gross Alpha/Beta	2	USDOE
		4	NTS
	H-3	2	USDOE
		4	NTS
	C-14	4	NTS
	Gamma	2	USDOE
		4	NTS
	Sr-89,90	2	USDOE
		4	NTS
Charcoal Cartridges	Gamma	4	NTS
Food	Gamma	2	USDOE
		4	NTS
		2	IAEA
Urine	H-3	3	RPB
	C-14	3	RPB
	Gamma	1	RPB

Table 7.03: Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
ALPHA (Figure 7.01)	NTS	7.04	2000/12/11	3.57 FAIL	NA
		7.04	2001/06/27	1.13	NA
		7.04	2001/08/30	2.14 FAIL	NA
		7.04	2001/12/14	1.69 FAIL	NA
		7.06	2000/12/11	1.03	NA
		7.06	2001/06/27	0.89	NA
		7.06	2001/08/30	1.14	NA
		7.06	2001/12/14	0.73	NA
	USDOE	7.08	2001/03/01	0.84	0.76 - 1.17
		7.08	2001/09/01	0.76	0.71 - 1.25
		7.09	2001/03/01	0.96	0.61 - 1.23
		7.09	2001/09/01	1.01	0.70 - 1.33
BETA (Figure 7.02)	NTS	7.04	2000/12/11	0.81	NA
		7.04	2001/06/27	0.88	NA
		7.04	2001/08/30	0.84	NA
		7.04	2001/12/14	1.08	NA
		7.06	2000/12/11	1.20	NA
		7.06	2001/06/27	1.16	NA
		7.06	2001/08/30	1.14	NA
		7.06	2001/12/14	1.11	NA
	USDOE	7.08	2001/03/01	1.16	0.74 - 1.38
		7.08	2001/09/01	0.93	0.76 - 1.17
		7.09	2001/03/01	1.16	0.79 - 1.35
		7.09	2001/09/01	0.95	0.76 - 1.06
Am-241 (Figure 7.03)	NTS	7.04	2000/12/11	1.25	NA
		7.04	2001/08/30	1.13	NA
		7.04	2001/12/14	1.23	NA
Ba-133 (Figure 7.04)	NTS	7.04	2001/12/14	0.94	NA
		7.05	2001/12/14	1.12	NA
		7.06	2001/12/14	1.06	NA
		7.07	2001/12/14	1.12	NA
C-14 (Figure 7.05)	NTS	7.06	2000/12/11	0.95	NA
		7.06	2001/06/27	0.32 FAIL	NA
		7.06	2001/08/30	1.10	NA
		7.06	2001/12/14	0.72	NA
	RPB	7.12	2001/05/17	0.95	0.85 - 1.11
		7.12	2001/05/17	0.94	0.89 - 1.08
		7.12	2001/05/17	0.91	0.87 - 1.05
Cd-109 (Figure 7.06)	NTS	7.04	2000/12/11	0.99	NA
		7.04	2001/06/27	0.94	NA
		7.04	2001/08/30	0.89	NA

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Cd-109 (Figure 7.06)	NTS	7.05	2000/12/11	0.90	NA
		7.05	2001/06/27	0.99	NA
		7.05	2001/08/30	0.94	NA
		7.06	2000/12/11	0.89	NA
		7.06	2001/06/27	0.93	NA
		7.06	2001/08/30	1.01	NA
		7.07	2000/12/11	0.77	NA
		7.07	2001/06/27	0.49 FAIL	NA
		7.07	2001/08/30	0.77	NA
Ce-139 (Figure 7.07)	NTS	7.04	2000/12/11	1.10	NA
		7.04	2001/06/27	1.09	NA
		7.04	2001/08/30	1.07	NA
		7.04	2001/12/14	0.90	NA
		7.05	2000/12/11	1.05	NA
		7.05	2001/06/27	1.06	NA
		7.05	2001/08/30	1.05	NA
		7.05	2001/12/14	0.95	NA
		7.06	2000/12/11	1.22	NA
		7.06	2001/06/27	1.07	NA
		7.06	2001/08/30	1.16	NA
		7.06	2001/12/14	1.03	NA
		7.07	2000/12/11	0.92	NA
		7.07	2001/06/27	0.59 FAIL	NA
		7.07	2001/08/30	0.97	NA
		7.07	2001/12/14	1.01	NA
Co-57 (Figure 7.08)	NTS	7.04	2000/12/11	1.21	NA
		7.04	2001/06/27	1.02	NA
		7.04	2001/08/30	0.96	NA
		7.05	2000/12/11	0.93	NA
		7.05	2001/06/27	1.10	NA
		7.05	2001/08/30	1.09	NA
		7.06	2000/12/11	1.07	NA
		7.06	2001/06/27	0.97	NA
		7.06	2001/08/30	1.12	NA
		7.07	2000/12/11	1.06	NA
		7.07	2001/06/27	0.53 FAIL	NA
		7.07	2001/08/30	0.88	NA
Co-60 (Figure 7.09)	NTS	7.04	2000/12/11	1.13	NA
		7.04	2001/06/27	1.00	NA
		7.04	2001/08/30	0.98	NA
		7.04	2001/12/14	0.98	NA

Table 7.03: Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
ALPHA (Figure 7.01)	NTS	7.04	2000/12/11	3.57 FAIL	NA
		7.04	2001/06/27	1.13	NA
		7.04	2001/08/30	2.14 FAIL	NA
		7.04	2001/12/14	1.69 FAIL	NA
		7.06	2000/12/11	1.03	NA
		7.06	2001/06/27	0.89	NA
		7.06	2001/08/30	1.14	NA
		7.06	2001/12/14	0.73	NA
	USDOE	7.08	2001/03/01	0.84	0.76 - 1.17
		7.08	2001/09/01	0.76	0.71 - 1.25
		7.09	2001/03/01	0.96	0.61 - 1.23
		7.09	2001/09/01	1.01	0.70 - 1.33
BETA (Figure 7.02)	NTS	7.04	2000/12/11	0.81	NA
		7.04	2001/06/27	0.88	NA
		7.04	2001/08/30	0.84	NA
		7.04	2001/12/14	1.08	NA
		7.06	2000/12/11	1.20	NA
		7.06	2001/06/27	1.16	NA
		7.06	2001/08/30	1.14	NA
		7.06	2001/12/14	1.11	NA
	USDOE	7.08	2001/03/01	1.16	0.74 - 1.38
		7.08	2001/09/01	0.93	0.76 - 1.17
		7.09	2001/03/01	1.16	0.79 - 1.35
		7.09	2001/09/01	0.95	0.76 - 1.06
Am-241 (Figure 7.03)	NTS	7.04	2000/12/11	1.25	NA
		7.04	2001/08/30	1.13	NA
		7.04	2001/12/14	1.23	NA
Ba-133 (Figure 7.04)	NTS	7.04	2001/12/14	0.94	NA
		7.05	2001/12/14	1.12	NA
		7.06	2001/12/14	1.06	NA
		7.07	2001/12/14	1.12	NA
C-14 (Figure 7.05)	NTS	7.06	2000/12/11	0.95	NA
		7.06	2001/06/27	0.32 FAIL	NA
		7.06	2001/08/30	1.10	NA
		7.06	2001/12/14	0.72	NA
	RPB	7.12	2001/05/17	0.95	0.85 - 1.11
		7.12	2001/05/17	0.94	0.89 - 1.08
		7.12	2001/05/17	0.91	0.87 - 1.05
Cd-109 (Figure 7.06)	NTS	7.04	2000/12/11	0.99	NA
		7.04	2001/06/27	0.94	NA
		7.04	2001/08/30	0.89	NA

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Cd-109 (Figure 7.06)	NTS	7.05	2000/12/11	0.90	NA
		7.05	2001/06/27	0.99	NA
		7.05	2001/08/30	0.94	NA
		7.06	2000/12/11	0.89	NA
		7.06	2001/06/27	0.93	NA
		7.06	2001/08/30	1.01	NA
		7.07	2000/12/11	0.77	NA
		7.07	2001/06/27	0.49 FAIL	NA
		7.07	2001/08/30	0.77	NA
Ce-139 (Figure 7.07)	NTS	7.04	2000/12/11	1.10	NA
		7.04	2001/06/27	1.09	NA
		7.04	2001/08/30	1.07	NA
		7.04	2001/12/14	0.90	NA
		7.05	2000/12/11	1.05	NA
		7.05	2001/06/27	1.06	NA
		7.05	2001/08/30	1.05	NA
		7.05	2001/12/14	0.95	NA
		7.06	2000/12/11	1.22	NA
		7.06	2001/06/27	1.07	NA
		7.06	2001/08/30	1.16	NA
		7.06	2001/12/14	1.03	NA
		7.07	2000/12/11	0.92	NA
		7.07	2001/06/27	0.59 FAIL	NA
		7.07	2001/08/30	0.97	NA
		7.07	2001/12/14	1.01	NA
Co-57 (Figure 7.08)	NTS	7.04	2000/12/11	1.21	NA
		7.04	2001/06/27	1.02	NA
		7.04	2001/08/30	0.96	NA
		7.05	2000/12/11	0.93	NA
		7.05	2001/06/27	1.10	NA
		7.05	2001/08/30	1.09	NA
		7.06	2000/12/11	1.07	NA
		7.06	2001/06/27	0.97	NA
		7.06	2001/08/30	1.12	NA
		7.07	2000/12/11	1.06	NA
		7.07	2001/06/27	0.53 FAIL	NA
		7.07	2001/08/30	0.88	NA
Co-60 (Figure 7.09)	NTS	7.04	2000/12/11	1.13	NA
		7.04	2001/06/27	1.00	NA
		7.04	2001/08/30	0.98	NA
		7.04	2001/12/14	0.98	NA

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	Agent	Table No.	Sample Date	NB Power/Agent	All Participants
Co-60 (Figure 7.09)	NTS	7.05	2000/12/11	0.99	NA
		7.05	2001/06/27	1.10	NA
		7.05	2001/08/30	0.96	NA
		7.05	2001/12/14	1.04	NA
		7.06	2000/12/11	0.96	NA
		7.06	2001/06/27	0.95	NA
		7.06	2001/08/30	1.13	NA
		7.06	2001/12/14	1.01	NA
		7.07	2000/12/11	1.01	NA
		7.07	2001/06/27	0.66 FAIL	NA
		7.07	2001/08/30	0.90	NA
		7.07	2001/12/14	1.22	NA
	RPB	7.12	2001/10/01	0.95	0.92 - 1.09
	USDOE	7.08	2001/03/01	0.93	0.93 - 1.12
		7.08	2001/09/01	0.92	0.89 - 1.11
		7.09	2001/03/01	0.97	0.88 - 1.13
		7.09	2001/09/01	0.96	0.87 - 1.17
		7.11	2001/03/01	1.09	0.84 - 1.26
		7.11	2001/09/01	1.01	0.82 - 1.28
Cs-134 (Figure 7.10)	IAEA	7.14	1991/12/31	1.58 FAIL	NA
		7.15	1987/08/31	0.74 FAIL	NA
	USDOE	7.09	2001/03/01	0.95	0.76 - 1.14
		7.09	2001/09/01	0.97	0.77 - 1.17
Cs-137 (Figure 7.11)	IAEA	7.13	1983/01/30	0.85 FAIL	NA
		7.13	1983/01/30	0.84 FAIL	NA
		7.14	1986/08/01	1.01	NA
		7.14	1991/12/31	1.23 FAIL	NA
		7.15	1987/08/31	0.66 FAIL	NA
	NTS	7.04	2000/12/11	1.21	NA
		7.04	2001/06/27	1.10	NA
		7.04	2001/08/30	1.06	NA
		7.04	2001/12/14	0.91	NA
		7.05	2000/12/11	0.94	NA
		7.05	2001/06/27	1.22	NA
		7.05	2001/08/30	0.98	NA
		7.05	2001/12/14	0.97	NA
		7.06	2000/12/11	0.92	NA
		7.06	2001/06/27	0.99	NA
		7.06	2001/08/30	1.09	NA
		7.06	2001/12/14	0.93	NA
		7.07	2000/12/11	0.95	NA

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Cs-137 (Figure 7.11)	NTS	7.07	2001/06/27	0.66 FAIL	NA
		7.07	2001/08/30	0.94	NA
		7.07	2001/12/14	1.09	NA
	RPB	7.12	2001/10/01	0.92	0.89 - 1.09
	USDOE	7.08	2001/03/01	0.90	0.93 - 1.15
		7.08	2001/09/01	0.99	0.93 - 1.16
		7.09	2001/03/01	0.98	0.88 - 1.22
		7.09	2001/09/01	1.01	0.90 - 1.24
		7.10	2001/03/01	0.94	0.85 - 1.19
		7.10	2001/09/01	0.87	0.86 - 1.16
		7.11	2001/03/01	1.08	0.86 - 1.23
		7.11	2001/09/01	1.02	0.85 - 1.27
Gamma	NRC	7.16	2001/07/03	0.92	NA
		7.16	2001/12/24	0.94	NA
H-3 (Figure 7.12)	NTS	7.06	2000/12/11	0.89	NA
		7.06	2001/06/27	1.18	NA
		7.06	2001/08/30	0.93	NA
		7.06	2001/12/14	0.93	NA
	USDOE	7.08	2001/03/01	0.93	0.66 - 1.57
		7.08	2001/09/01	0.98	0.76 - 1.34
	RPB	7.12	2001/04/26	0.91	0.76 - 1.09
		7.12	2001/04/26	0.83	0.71 - 1.08
		7.12	2001/04/26	0.91	0.75 - 1.12
Hg-203 (Figure 7.13)	NTS	7.04	2000/12/11	1.23	NA
		7.05	2000/12/11	3.46	NA
		7.06	2000/12/11	3.09	NA
		7.07	2000/12/11	2.40	NA
K-40 (Figure 7.14)	IAEA	7.14	1986/08/01	1.09 FAIL	NA
		7.14	1991/12/31	1.34 FAIL	NA
		7.15	1987/08/31	0.77 FAIL	NA
	USDOE	7.10	2001/03/01	0.99	0.83 - 1.24
		7.10	2001/09/01	0.93	0.85 - 1.17
		7.11	2001/03/01	1.33	0.84 - 1.30
		7.11	2001/09/01	1.09	0.84 - 1.29
Mn-54 (Figure 7.15)	NTS	7.04	2001/12/14	0.95	NA
		7.05	2001/12/14	1.06	NA
		7.06	2001/12/14	1.03	NA
		7.07	2001/12/14	1.03	NA
	USDOE	7.09	2001/03/01	1.07	0.86 - 1.23

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Co-60 (Figure 7.09)	NTS	7.05	2000/12/11	0.99	NA
		7.05	2001/06/27	1.10	NA
		7.05	2001/08/30	0.96	NA
		7.05	2001/12/14	1.04	NA
		7.06	2000/12/11	0.96	NA
		7.06	2001/06/27	0.95	NA
		7.06	2001/08/30	1.13	NA
		7.06	2001/12/14	1.01	NA
		7.07	2000/12/11	1.01	NA
		7.07	2001/06/27	0.66 FAIL	NA
		7.07	2001/08/30	0.90	NA
		7.07	2001/12/14	1.22	NA
	RPB	7.12	2001/10/01	0.95	0.92 - 1.09
	USDOE	7.08	2001/03/01	0.93	0.93 - 1.12
		7.08	2001/09/01	0.92	0.89 - 1.11
		7.09	2001/03/01	0.97	0.88 - 1.13
		7.09	2001/09/01	0.96	0.87 - 1.17
		7.11	2001/03/01	1.09	0.84 - 1.26
		7.11	2001/09/01	1.01	0.82 - 1.28
Cs-134 (Figure 7.10)	IAEA	7.14	1991/12/31	1.58 FAIL	NA
		7.15	1987/08/31	0.74 FAIL	NA
	USDOE	7.09	2001/03/01	0.95	0.76 - 1.14
		7.09	2001/09/01	0.97	0.77 - 1.17
Cs-137 (Figure 7.11)	IAEA	7.13	1983/01/30	0.85 FAIL	NA
		7.13	1983/01/30	0.84 FAIL	NA
		7.14	1986/08/01	1.01	NA
		7.14	1991/12/31	1.23 FAIL	NA
		7.15	1987/08/31	0.66 FAIL	NA
	NTS	7.04	2000/12/11	1.21	NA
		7.04	2001/06/27	1.10	NA
		7.04	2001/08/30	1.06	NA
		7.04	2001/12/14	0.91	NA
		7.05	2000/12/11	0.94	NA
		7.05	2001/06/27	1.22	NA
		7.05	2001/08/30	0.98	NA
		7.05	2001/12/14	0.97	NA
		7.06	2000/12/11	0.92	NA
		7.06	2001/06/27	0.99	NA
		7.06	2001/08/30	1.09	NA
		7.06	2001/12/14	0.93	NA
		7.07	2000/12/11	0.95	NA

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	Agent	Table No.	Sample Date	NB Power/Agent	All Participants
Cs-137 (Figure 7.11)	NTS	7.07	2001/06/27	0.66 FAIL	NA
		7.07	2001/08/30	0.94	NA
		7.07	2001/12/14	1.09	NA
	RPB	7.12	2001/10/01	0.92	0.89 - 1.09
	USDOE	7.08	2001/03/01	0.90	0.93 - 1.15
		7.08	2001/09/01	0.99	0.93 - 1.16
		7.09	2001/03/01	0.98	0.88 - 1.22
		7.09	2001/09/01	1.01	0.90 - 1.24
		7.10	2001/03/01	0.94	0.85 - 1.19
		7.10	2001/09/01	0.87	0.86 - 1.16
		7.11	2001/03/01	1.08	0.86 - 1.23
		7.11	2001/09/01	1.02	0.85 - 1.27
Gamma	NRC	7.16	2001/07/03	0.92	NA
		7.16	2001/12/24	0.94	NA
H-3 (Figure 7.12)	NTS	7.06	2000/12/11	0.89	NA
		7.06	2001/06/27	1.18	NA
		7.06	2001/08/30	0.93	NA
		7.06	2001/12/14	0.93	NA
	USDOE	7.08	2001/03/01	0.93	0.66 - 1.57
		7.08	2001/09/01	0.98	0.76 - 1.34
	RPB	7.12	2001/04/26	0.91	0.76 - 1.09
		7.12	2001/04/26	0.83	0.71 - 1.08
		7.12	2001/04/26	0.91	0.75 - 1.12
Hg-203 (Figure 7.13)	NTS	7.04	2000/12/11	1.23	NA
		7.05	2000/12/11	3.46	NA
		7.06	2000/12/11	3.09	NA
		7.07	2000/12/11	2.40	NA
K-40 (Figure 7.14)	IAEA	7.14	1986/08/01	1.09 FAIL	NA
		7.14	1991/12/31	1.34 FAIL	NA
		7.15	1987/08/31	0.77 FAIL	NA
	USDOE	7.10	2001/03/01	0.99	0.83 - 1.24
		7.10	2001/09/01	0.93	0.85 - 1.17
		7.11	2001/03/01	1.33	0.84 - 1.30
		7.11	2001/09/01	1.09	0.84 - 1.29
Mn-54 (Figure 7.15)	NTS	7.04	2001/12/14	0.95	NA
		7.05	2001/12/14	1.06	NA
		7.06	2001/12/14	1.03	NA
		7.07	2001/12/14	1.03	NA
	USDOE	7.09	2001/03/01	1.07	0.86 - 1.23

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Mn-54	USDOE	7.09	2001/09/01	1.03	0.88 - 1.26
Sn-113 (Figure 7.16)	NTS	7.04	2000/12/11	1.25	NA
		7.04	2001/06/27	1.17	NA
		7.04	2001/08/30	1.08	NA
		7.05	2000/12/11	0.56	NA
		7.05	2001/06/27	1.34	NA
		7.05	2001/08/30	1.29	NA
		7.06	2000/12/11	0.50	NA
		7.06	2001/06/27	1.02	NA
		7.06	2001/08/30	1.47	NA
		7.07	2000/12/11	0.98	NA
		7.07	2001/06/27	0.62 FAIL	NA
		7.07	2001/08/30	0.97	NA
Sr-89 (Figure 7.17)	NTS	7.04	2000/12/11	0.96	NA
		7.04	2001/06/27	0.88	NA
		7.04	2001/08/30	1.00	NA
		7.04	2001/12/14	0.97	NA
		7.06	2000/12/11	1.21	NA
		7.06	2001/06/27	0.07 FAIL	NA
		7.06	2001/08/30	1.14	NA
		7.06	2001/12/14	0.88	NA
Sr-90 (Figure 7.18)	NTS	7.04	2000/12/11	0.95	NA
		7.04	2001/06/27	1.20	NA
		7.04	2001/08/30	0.93	NA
		7.04	2001/12/14	0.89	NA
		7.06	2000/12/11	0.95	NA
		7.06	2001/06/27	1.09	NA
		7.06	2001/08/30	0.96	NA
		7.06	2001/12/14	0.96	NA
	USDOE	7.08	2001/03/01	0.82	0.74 - 1.22
		7.08	2001/09/01	0.39 FAIL	0.75 - 1.31
		7.09	2001/03/01	0.82	0.68 - 1.36
		7.09	2001/09/01	0.89	0.69 - 1.37
Y-88 (Figure 7.19)	NTS	7.04	2000/12/11	1.11	NA
		7.04	2001/06/27	1.10	NA
		7.04	2001/08/30	0.98	NA
		7.05	2000/12/11	0.95	NA
		7.05	2001/06/27	1.25	NA
		7.05	2001/08/30	0.98	NA
		7.06	2000/12/11	1.13	NA
		7.06	2001/06/27	0.92	NA

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Y-88	NTS	7.06	2001/08/30	1.56	NA
		7.07	2000/12/11	1.01	NA
		7.07	2001/06/27	0.71 FAIL	NA
		7.07	2001/08/30	0.99	NA

NA: Not Applicable

Table 7.04: NTS Air Filter

Analysis	Sample Date	NTS	NB Power (pCi/filter ± 2 sigma)	NB Power/ NTS (ratio)
ALPHA	2000/12/11	60 +- 6	214 +- 13	3.57 FAIL
	2001/06/27	101 +- 10	114 +- 7	1.13
	2001/08/30	70 +- 7	150 +- 10	2.14 FAIL
	2001/12/14	117 +- 20	198 +- 16	1.69 FAIL
Am-241	2000/12/11	60 +- 6	75 +- 8	1.25
	2001/08/30	70 +- 7	79 +- 9	1.13
	2001/12/14	117 +- 20	144 +- 15	1.23
BETA	2000/12/11	3970 +- 397	3210 +- 90	0.81
	2001/06/27	1730 +- 173	1530 +- 43	0.88
	2001/08/30	3790 +- 400	3180 +- 89	0.84
	2001/12/14	4720 +- 250	5090 +- 143	1.08
Ba-133	2001/12/14	530 +- 55	500 +- 32	0.94
Cd-109	2000/12/11	3360 +- 181	3330 +- 206	0.99
	2001/06/27	1440 +- 78	1350 +- 91	0.94
	2001/08/30	3280 +- 400	2930 +- 182	0.89
Ce-139	2000/12/11	48 +- 2	53 +- 4	1.10
	2001/06/27	10 +- 0	11 +- 1	1.09
	2001/08/30	19 +- 2	20 +- 2	1.07
	2001/12/14	32 +- 4	28 +- 3	0.90
Co-57	2000/12/11	63 +- 3	76 +- 9	1.21
	2001/06/27	22 +- 1	23 +- 2	1.02
	2001/08/30	47 +- 5	45 +- 3	0.96
Co-60	2000/12/11	225 +- 11	254 +- 13	1.13
	2001/06/27	121 +- 6	121 +- 7	1.00
	2001/08/30	295 +- 33	289 +- 14	0.98
	2001/12/14	531 +- 50	520 +- 23	0.98
Cs-137	2000/12/11	149 +- 8	181 +- 12	1.21
	2001/06/27	85 +- 5	94 +- 7	1.10
	2001/08/30	212 +- 24	224 +- 15	1.06
	2001/12/14	4190 +- 415	3820 +- 218	0.91

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Mn-54	USDOE	7.09	2001/09/01	1.03	0.88 - 1.26
Sn-113 (Figure 7.16)	NTS	7.04	2000/12/11	1.25	NA
		7.04	2001/06/27	1.17	NA
		7.04	2001/08/30	1.08	NA
		7.05	2000/12/11	0.56	NA
		7.05	2001/06/27	1.34	NA
		7.05	2001/08/30	1.29	NA
		7.06	2000/12/11	0.50	NA
		7.06	2001/06/27	1.02	NA
		7.06	2001/08/30	1.47	NA
		7.07	2000/12/11	0.98	NA
		7.07	2001/06/27	0.62 FAIL	NA
		7.07	2001/08/30	0.97	NA
Sr-89 (Figure 7.17)	NTS	7.04	2000/12/11	0.96	NA
		7.04	2001/06/27	0.88	NA
		7.04	2001/08/30	1.00	NA
		7.04	2001/12/14	0.97	NA
		7.06	2000/12/11	1.21	NA
		7.06	2001/06/27	0.07 FAIL	NA
		7.06	2001/08/30	1.14	NA
		7.06	2001/12/14	0.88	NA
Sr-90 (Figure 7.18)	NTS	7.04	2000/12/11	0.95	NA
		7.04	2001/06/27	1.20	NA
		7.04	2001/08/30	0.93	NA
		7.04	2001/12/14	0.89	NA
		7.06	2000/12/11	0.95	NA
		7.06	2001/06/27	1.09	NA
		7.06	2001/08/30	0.96	NA
		7.06	2001/12/14	0.96	NA
	USDOE	7.08	2001/03/01	0.82	0.74 - 1.22
		7.08	2001/09/01	0.39 FAIL	0.75 - 1.31
		7.09	2001/03/01	0.82	0.68 - 1.36
		7.09	2001/09/01	0.89	0.69 - 1.37
Y-88 (Figure 7.19)	NTS	7.04	2000/12/11	1.11	NA
		7.04	2001/06/27	1.10	NA
		7.04	2001/08/30	0.98	NA
		7.05	2000/12/11	0.95	NA
		7.05	2001/06/27	1.25	NA
		7.05	2001/08/30	0.98	NA
		7.06	2000/12/11	1.13	NA
		7.06	2001/06/27	0.92	NA

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	*Agent*	*Table No.*	*Sample Date*	*NB Power/Agent*	*All Participants*
Y-88	NTS	7.06	2001/08/30	1.56	NA
		7.07	2000/12/11	1.01	NA
		7.07	2001/06/27	0.71 FAIL	NA
		7.07	2001/08/30	0.99	NA

NA: Not Applicable

Table 7.04: NTS Air Filter

Analysis	Sample Date	NTS	NB Power (pCi/filter ± 2 sigma)	NB Power/ NTS (ratio)
ALPHA	2000/12/11	60 +- 6	214 +- 13	3.57 FAIL
	2001/06/27	101 +- 10	114 +- 7	1.13
	2001/08/30	70 +- 7	150 +- 10	2.14 FAIL
	2001/12/14	117 +- 20	198 +- 16	1.69 FAIL
Am-241	2000/12/11	60 +- 6	75 +- 8	1.25
	2001/08/30	70 +- 7	79 +- 9	1.13
	2001/12/14	117 +- 20	144 +- 15	1.23
BETA	2000/12/11	3970 +- 397	3210 +- 90	0.81
	2001/06/27	1730 +- 173	1530 +- 43	0.88
	2001/08/30	3790 +- 400	3180 +- 89	0.84
	2001/12/14	4720 +- 250	5090 +- 143	1.08
Ba-133	2001/12/14	530 +- 55	500 +- 32	0.94
Cd-109	2000/12/11	3360 +- 181	3330 +- 206	0.99
	2001/06/27	1440 +- 78	1350 +- 91	0.94
	2001/08/30	3280 +- 400	2930 +- 182	0.89
Ce-139	2000/12/11	48 +- 2	53 +- 4	1.10
	2001/06/27	10 +- 0	11 +- 1	1.09
	2001/08/30	19 +- 2	20 +- 2	1.07
	2001/12/14	32 +- 4	28 +- 3	0.90
Co-57	2000/12/11	63 +- 3	76 +- 9	1.21
	2001/06/27	22 +- 1	23 +- 2	1.02
	2001/08/30	47 +- 5	45 +- 3	0.96
Co-60	2000/12/11	225 +- 11	254 +- 13	1.13
	2001/06/27	121 +- 6	121 +- 7	1.00
	2001/08/30	295 +- 33	289 +- 14	0.98
	2001/12/14	531 +- 50	520 +- 23	0.98
Cs-137	2000/12/11	149 +- 8	181 +- 12	1.21
	2001/06/27	85 +- 5	94 +- 7	1.10
	2001/08/30	212 +- 24	224 +- 15	1.06
	2001/12/14	4190 +- 415	3820 +- 218	0.91

Table 7.04 (continued): NTS Air Filter

Analysis	Sample Date	NTS	NB Power (pCi/filter ± 2 sigma)	NB Power/ NTS (ratio)
Hg-203	2000/12/11	10 +- 0	12 +- 0	1.23
Mn-54	2001/12/14	79 +- 8	75 +- 7	0.95
Sn-113	2000/12/11	62 +- 3	78 +- 7	1.25
	2001/06/27	11 +- 1	13 +- 2	1.17
	2001/08/30	19 +- 2	20 +- 3	1.08
Sr-89	2000/12/11	52 +- 5	49 +- 1	0.96
	2001/06/27	80 +- 8	70 +- 2	0.88
	2001/08/30	55 +- 5	55 +- 1	1.00
	2001/12/14	65 +- 7	62 +- 2	0.97
Sr-90	2000/12/11	30 +- 3	28 +- 1	0.95
	2001/06/27	29 +- 3	35 +- 1	1.20
	2001/08/30	29 +- 3	27 +- 1	0.93
	2001/12/14	44 +- 4	39 +- 4	0.89
Y-88	2000/12/11	101 +- 5	112 +- 8	1.11
	2001/06/27	16 +- 1	18 +- 2	1.10
	2001/08/30	27 +- 3	26 +- 3	0.98

Table 7.05: NTS Food

Analysis	Sample Date	NTS	NB Power (pCi/kg ± 2 sigma)	NB Power/ NTS (ratio)
Ba-133	2001/12/14	1150 +- 120	1290 +- 127	1.12
Cd-109	2000/12/11	5620 +- 303	5050 +- 401	0.90
	2001/06/27	7080 +- 382	7030 +- 596	0.99
	2001/08/30	6660 +- 600	6270 +- 467	0.94
Ce-139	2000/12/11	81 +- 4	85 +- 9	1.05
	2001/06/27	51 +- 2	54 +- 9	1.06
	2001/08/30	38 +- 4	40 +- 6	1.05
	2001/12/14	69 +- 7	65 +- 12	0.95
Co-57	2000/12/11	106 +- 5	99 +- 10	0.93
	2001/06/27	108 +- 5	119 +- 13	1.10
	2001/08/30	95 +- 9	104 +- 10	1.09
Co-60	2000/12/11	374 +- 19	372 +- 24	0.99
	2001/06/27	594 +- 30	656 +- 41	1.10
	2001/08/30	598 +- 60	576 +- 32	0.96
	2001/12/14	1150 +- 120	1200 +- 61	1.04

Table 7.05 (continued): NTS Food

Analysis	Sample Date	NTS	NB Power (pCi/kg ± 2 sigma)	NB Power/ NTS (ratio)
Cs-137	2000/12/11	263 +- 14	248 +- 22	0.94
	2001/06/27	417 +- 22	508 +- 44	1.22
	2001/08/30	455 +- 48	446 +- 34	0.98
	2001/12/14	9080 +- 910	8800 +- 519	0.97
Hg-203	2000/12/11	17 +- 1	59 +- 0	3.46
Mn-54	2001/12/14	170 +- 20	181 +- 21	1.06
Sn-113	2000/12/11	104 +- 5	58 +- 0	0.56
	2001/06/27	54 +- 3	72 +- 15	1.34
	2001/08/30	38 +- 4	49 +- 10	1.29
Y-88	2000/12/11	168 +- 8	160 +- 18	0.95
	2001/06/27	80 +- 4	100 +- 15	1.25
	2001/08/30	54 +- 5	53 +- 9	0.98

Table 7.06: NTS Water

Analysis	Sample Date	NTS	NB Power (pCi/L ± 2 sigma)	NB Power/ NTS (ratio)
ALPHA	2000/12/11	30 +- 3	31 +- 2	1.03
	2001/06/27	50 +- 5	45 +- 3	0.89
	2001/08/30	59 +- 6	67 +- 4	1.14
	2001/12/14	117 +- 20	86 +- 5	0.73
BETA	2000/12/11	45 +- 4	53 +- 3	1.20
	2001/06/27	50 +- 5	58 +- 4	1.16
	2001/08/30	88 +- 9	100 +- 5	1.14
	2001/12/14	116 +- 15	129 +- 7	1.11
Ba-133	2001/12/14	883 +- 90	937 +- 113	1.06
C-14	2000/12/11	880 +- 88	833 +- 111	0.95
	2001/06/27	3520 +- 352	1110 +- 122	0.32 FAIL
	2001/08/30	7040 +- 80	7720 +- 267	1.10
	2001/12/14	3510 +- 420	2530 +- 156	0.72
Cd-109	2000/12/11	5780 +- 312	5130 +- 504	0.89
	2001/06/27	10300 +- 554	9580 +- 844	0.93
	2001/08/30	3940 +- 400	3980 +- 406	1.01

Table 7.04 (continued): NTS Air Filter

Analysis	Sample Date	NTS	NB Power (pCi/filter ± 2 sigma)	NB Power/ NTS (ratio)
Hg-203	2000/12/11	10 +- 0	12 +- 0	1.23
Mn-54	2001/12/14	79 +- 8	75 +- 7	0.95
Sn-113	2000/12/11	62 +- 3	78 +- 7	1.25
	2001/06/27	11 +- 1	13 +- 2	1.17
	2001/08/30	19 +- 2	20 +- 3	1.08
Sr-89	2000/12/11	52 +- 5	49 +- 1	0.96
	2001/06/27	80 +- 8	70 +- 2	0.88
	2001/08/30	55 +- 5	55 +- 1	1.00
	2001/12/14	65 +- 7	62 +- 2	0.97
Sr-90	2000/12/11	30 +- 3	28 +- 1	0.95
	2001/06/27	29 +- 3	35 +- 1	1.20
	2001/08/30	29 +- 3	27 +- 1	0.93
	2001/12/14	44 +- 4	39 +- 4	0.89
Y-88	2000/12/11	101 +- 5	112 +- 8	1.11
	2001/06/27	16 +- 1	18 +- 2	1.10
	2001/08/30	27 +- 3	26 +- 3	0.98

Table 7.05: NTS Food

Analysis	Sample Date	NTS	NB Power (pCi/kg ± 2 sigma)	NB Power/ NTS (ratio)
Ba-133	2001/12/14	1150 +- 120	1290 +- 127	1.12
Cd-109	2000/12/11	5620 +- 303	5050 +- 401	0.90
	2001/06/27	7080 +- 382	7030 +- 596	0.99
	2001/08/30	6660 +- 600	6270 +- 467	0.94
Ce-139	2000/12/11	81 +- 4	85 +- 9	1.05
	2001/06/27	51 +- 2	54 +- 9	1.06
	2001/08/30	38 +- 4	40 +- 6	1.05
	2001/12/14	69 +- 7	65 +- 12	0.95
Co-57	2000/12/11	106 +- 5	99 +- 10	0.93
	2001/06/27	108 +- 5	119 +- 13	1.10
	2001/08/30	95 +- 9	104 +- 10	1.09
Co-60	2000/12/11	374 +- 19	372 +- 24	0.99
	2001/06/27	594 +- 30	656 +- 41	1.10
	2001/08/30	598 +- 60	576 +- 32	0.96
	2001/12/14	1150 +- 120	1200 +- 61	1.04

Table 7.05 (continued): NTS Food

Analysis	Sample Date	NTS	NB Power (pCi/kg ± 2 sigma)	NB Power/ NTS (ratio)
Cs-137	2000/12/11	263 +- 14	248 +- 22	0.94
	2001/06/27	417 +- 22	508 +- 44	1.22
	2001/08/30	455 +- 48	446 +- 34	0.98
	2001/12/14	9080 +- 910	8800 +- 519	0.97
Hg-203	2000/12/11	17 +- 1	59 +- 0	3.46
Mn-54	2001/12/14	170 +- 20	181 +- 21	1.06
Sn-113	2000/12/11	104 +- 5	58 +- 0	0.56
	2001/06/27	54 +- 3	72 +- 15	1.34
	2001/08/30	38 +- 4	49 +- 10	1.29
Y-88	2000/12/11	168 +- 8	160 +- 18	0.95
	2001/06/27	80 +- 4	100 +- 15	1.25
	2001/08/30	54 +- 5	53 +- 9	0.98

Table 7.06: NTS Water

Analysis	Sample Date	NTS	NB Power (pCi/L ± 2 sigma)	NB Power/ NTS (ratio)
ALPHA	2000/12/11	30 +- 3	31 +- 2	1.03
	2001/06/27	50 +- 5	45 +- 3	0.89
	2001/08/30	59 +- 6	67 +- 4	1.14
	2001/12/14	117 +- 20	86 +- 5	0.73
BETA	2000/12/11	45 +- 4	53 +- 3	1.20
	2001/06/27	50 +- 5	58 +- 4	1.16
	2001/08/30	88 +- 9	100 +- 5	1.14
	2001/12/14	116 +- 15	129 +- 7	1.11
Ba-133	2001/12/14	883 +- 90	937 +- 113	1.06
C-14	2000/12/11	880 +- 88	833 +- 111	0.95
	2001/06/27	3520 +- 352	1110 +- 122	0.32 FAIL
	2001/08/30	7040 +- 80	7720 +- 267	1.10
	2001/12/14	3510 +- 420	2530 +- 156	0.72
Cd-109	2000/12/11	5780 +- 312	5130 +- 504	0.89
	2001/06/27	10300 +- 554	9580 +- 844	0.93
	2001/08/30	3940 +- 400	3980 +- 406	1.01

Table 7.06 (continued): NTS Water

Analysis	Sample Date	NTS	NB Power (pCi/L ± 2 sigma)	NB Power/ NTS (ratio)
Ce-139	2000/12/11	83 +- 4	102 +- 13	1.22
	2001/06/27	73 +- 3	78 +- 10	1.07
	2001/08/30	23 +- 3	26 +- 5	1.16
	2001/12/14	53 +- 6	55 +- 11	1.03
Co-57	2000/12/11	109 +- 5	117 +- 24	1.07
	2001/06/27	157 +- 8	153 +- 15	0.97
	2001/08/30	56 +- 6	63 +- 8	1.12
Co-60	2000/12/11	385 +- 20	370 +- 32	0.96
	2001/06/27	855 +- 44	816 +- 58	0.95
	2001/08/30	354 +- 37	400 +- 32	1.13
	2001/12/14	885 +- 90	894 +- 63	1.01
Cs-137	2000/12/11	271 +- 14	249 +- 27	0.92
	2001/06/27	639 +- 34	631 +- 57	0.99
	2001/08/30	254 +- 26	277 +- 29	1.09
	2001/12/14	6990 +- 700	6520 +- 168	0.93
H-3	2000/12/11	2280 +- 274	2030 +- 206	0.89
	2001/06/27	974 +- 146	1150 +- 190	1.18
	2001/08/30	35100 +- 350	32600 +- 692	0.93
	2001/12/14	8630 +- 560	7990 +- 309	0.93
Hg-203	2000/12/11	18 +- 1	54 +- 0	3.09
Mn-54	2001/12/14	131 +- 15	135 +- 19	1.03
Sn-113	2000/12/11	108 +- 5	54 +- 0	0.5
	2001/06/27	78 +- 4	79 +- 14	1.02
	2001/08/30	22 +- 3	33 +- 9	1.47
Sr-89	2000/12/11	43 +- 4	52 +- 3	1.21
	2001/06/27	29 +- 3	2 +- 0	0.07 FAIL
	2001/08/30	24 +- 2	27 +- 2	1.14
	2001/12/14	65 +- 7	57 +- 3	0.88
Sr-90	2000/12/11	30 +- 3	28 +- 2	0.95
	2001/06/27	59 +- 3	64 +- 4	1.09
	2001/08/30	88 +- 5	84 +- 4	0.96
	2001/12/14	58 +- 5	55 +- 3	0.96
Y-88	2000/12/11	176 +- 9	199 +- 23	1.13
	2001/06/27	114 +- 6	105 +- 15	0.92
	2001/08/30	32 +- 3	50 +- 0	1.56

Table 7.07: NTS Charcoal Cartridge

Analysis	Sample Date	NTS	NB Power (pCi/cartridge ± 2 sigma)	NB Power/ NTS (ratio)
Ba-133	2001/12/14	618 +- 96	695 +- 53	1.12
Cd-109	2000/12/11	3370 +- 337	2600 +- 187	0.77
	2001/06/27	14400 +- 1440	7110 +- 444	0.49 FAIL
	2001/08/30	6560 +- 650	5070 +- 326	0.77
Ce-139	2000/12/11	49 +- 2	45 +- 4	0.92
	2001/06/27	103 +- 5	61 +- 5	0.59 FAIL
	2001/08/30	37 +- 4	36 +- 4	0.97
	2001/12/14	37 +- 3	37 +- 5	1.01
Co-57	2000/12/11	63 +- 3	67 +- 12	1.06
	2001/06/27	221 +- 11	118 +- 8	0.53 FAIL
	2001/08/30	94 +- 9	83 +- 6	0.88
Co-60	2000/12/11	226 +- 12	229 +- 13	1.01
	2001/06/27	1200 +- 61	794 +- 36	0.66 FAIL
	2001/08/30	589 +- 55	529 +- 26	0.90
	2001/12/14	620 +- 80	757 +- 35	1.22
Cs-137	2000/12/11	158 +- 8	150 +- 12	0.95
	2001/06/27	851 +- 45	563 +- 36	0.66 FAIL
	2001/08/30	424 +- 40	397 +- 27	0.94
	2001/12/14	4890 +- 500	5310 +- 305	1.09
Hg-203	2000/12/11	10 +- 0	25 +- 0	2.40
Mn-54	2001/12/14	92 +- 8	95 +- 10	1.03
Sn-113	2000/12/11	63 +- 3	61 +- 8	0.98
	2001/06/27	110 +- 5	68 +- 8	0.62 FAIL
	2001/08/30	37 +- 4	36 +- 5	0.97
Y-88	2000/12/11	103 +- 5	104 +- 10	1.01
	2001/06/27	161 +- 8	115 +- 9	0.71 FAIL
	2001/08/30	54 +- 5	53 +- 6	0.99

Table 7.06 (continued): NTS Water

Analysis	Sample Date	NTS	NB Power (pCi/L ± 2 sigma)	NB Power/ NTS (ratio)
Ce-139	2000/12/11	83 +- 4	102 +- 13	1.22
	2001/06/27	73 +- 3	78 +- 10	1.07
	2001/08/30	23 +- 3	26 +- 5	1.16
	2001/12/14	53 +- 6	55 +- 11	1.03
Co-57	2000/12/11	109 +- 5	117 +- 24	1.07
	2001/06/27	157 +- 8	153 +- 15	0.97
	2001/08/30	56 +- 6	63 +- 8	1.12
Co-60	2000/12/11	385 +- 20	370 +- 32	0.96
	2001/06/27	855 +- 44	816 +- 58	0.95
	2001/08/30	354 +- 37	400 +- 32	1.13
	2001/12/14	885 +- 90	894 +- 63	1.01
Cs-137	2000/12/11	271 +- 14	249 +- 27	0.92
	2001/06/27	639 +- 34	631 +- 57	0.99
	2001/08/30	254 +- 26	277 +- 29	1.09
	2001/12/14	6990 +- 700	6520 +- 168	0.93
H-3	2000/12/11	2280 +- 274	2030 +- 206	0.89
	2001/06/27	974 +- 146	1150 +- 190	1.18
	2001/08/30	35100 +- 350	32600 +- 692	0.93
	2001/12/14	8630 +- 560	7990 +- 309	0.93
Hg-203	2000/12/11	18 +- 1	54 +- 0	3.09
Mn-54	2001/12/14	131 +- 15	135 +- 19	1.03
Sn-113	2000/12/11	108 +- 5	54 +- 0	0.5
	2001/06/27	78 +- 4	79 +- 14	1.02
	2001/08/30	22 +- 3	33 +- 9	1.47
Sr-89	2000/12/11	43 +- 4	52 +- 3	1.21
	2001/06/27	29 +- 3	2 +- 0	0.07 FAIL
	2001/08/30	24 +- 2	27 +- 2	1.14
	2001/12/14	65 +- 7	57 +- 3	0.88
Sr-90	2000/12/11	30 +- 3	28 +- 2	0.95
	2001/06/27	59 +- 3	64 +- 4	1.09
	2001/08/30	88 +- 5	84 +- 4	0.96
	2001/12/14	58 +- 5	55 +- 3	0.96
Y-88	2000/12/11	176 +- 9	199 +- 23	1.13
	2001/06/27	114 +- 6	105 +- 15	0.92
	2001/08/30	32 +- 3	50 +- 0	1.56

Table 7.07: NTS Charcoal Cartridge

Analysis	Sample Date	NTS	NB Power (pCi/cartridge ± 2 sigma)	NB Power/ NTS (ratio)
Ba-133	2001/12/14	618 +- 96	695 +- 53	1.12
Cd-109	2000/12/11	3370 +- 337	2600 +- 187	0.77
	2001/06/27	14400 +- 1440	7110 +- 444	0.49 FAIL
	2001/08/30	6560 +- 650	5070 +- 326	0.77
Ce-139	2000/12/11	49 +- 2	45 +- 4	0.92
	2001/06/27	103 +- 5	61 +- 5	0.59 FAIL
	2001/08/30	37 +- 4	36 +- 4	0.97
	2001/12/14	37 +- 3	37 +- 5	1.01
Co-57	2000/12/11	63 +- 3	67 +- 12	1.06
	2001/06/27	221 +- 11	118 +- 8	0.53 FAIL
	2001/08/30	94 +- 9	83 +- 6	0.88
Co-60	2000/12/11	226 +- 12	229 +- 13	1.01
	2001/06/27	1200 +- 61	794 +- 36	0.66 FAIL
	2001/08/30	589 +- 55	529 +- 26	0.90
	2001/12/14	620 +- 80	757 +- 35	1.22
Cs-137	2000/12/11	158 +- 8	150 +- 12	0.95
	2001/06/27	851 +- 45	563 +- 36	0.66 FAIL
	2001/08/30	424 +- 40	397 +- 27	0.94
	2001/12/14	4890 +- 500	5310 +- 305	1.09
Hg-203	2000/12/11	10 +- 0	25 +- 0	2.40
Mn-54	2001/12/14	92 +- 8	95 +- 10	1.03
Sn-113	2000/12/11	63 +- 3	61 +- 8	0.98
	2001/06/27	110 +- 5	68 +- 8	0.62 FAIL
	2001/08/30	37 +- 4	36 +- 5	0.97
Y-88	2000/12/11	103 +- 5	104 +- 10	1.01
	2001/06/27	161 +- 8	115 +- 9	0.71 FAIL
	2001/08/30	54 +- 5	53 +- 6	0.99

Table 7.08: USDOE Water

Analysis	Sample Date	USDOE	*All Participants (Bq/L ± 2 sigma)	NB Power (Bq/L ± 2 sigma)	NB Power/ USDOE (ratio)
ALPHA	2001/03/01	1900 +- 190	1832 +- 387	1590 +- 85	0.84
	2001/09/01	1150 +- 115	1129 +- 309	871 +- 54	0.76
BETA	2001/03/01	1300 +- 100	1377 +- 414	1510 +- 77	1.16
	2001/09/01	7970 +- 800	7659 +- 1640	7440 +- 308	0.93
Co-60	2001/03/01	98 +- 4	101 +- 9	91 +- 5	0.93
	2001/09/01	209 +- 8	209 +- 22	192 +- 10	0.92
Cs-137	2001/03/01	73 +- 4	76 +- 8	66 +- 5	0.90
	2001/09/01	45 +- 2	47 +- 5	45 +- 4	0.99
H-3	2001/03/01	79 +- 2	89 +- 36	74 +- 8	0.93
	2001/09/01	207 +- 3	217 +- 60	203 +- 10	0.98
Sr-90	2001/03/01	4 +- 0	4 +- 1	4 +- 0	0.82
	2001/09/01	4 +- 0	4 +- 1	1 +- 0	0.39 FAIL

*: Excluding those results significantly different from the population mean.

Table 7.09: USDOE Air Filter

Analysis	Sample Date	USDOE	*All Participants (Bq/filter ± 2 sigma)	NB Power (Bq/filter ± 2 sigma)	NB Power/ USDOE (ratio)
ALPHA	2001/03/01	4 +- 0	4 +- 1	4 +- 0	0.96
	2001/09/01	5 +- 1	5 +- 2	5 +- 0	1.01
BETA	2001/03/01	3 +- 0	3 +- 1	3 +- 0	1.16
	2001/09/01	13 +- 1	12 +- 2	12 +- 0	0.95
Co-60	2001/03/01	19 +- 1	19 +- 2	19 +- 1	0.97
	2001/09/01	18 +- 0	18 +- 3	17 +- 1	0.96
Cs-134	2001/03/01	3 +- 0	3 +- 1	3 +- 0	0.95
	2001/09/01	13 +- 0	13 +- 3	13 +- 1	0.97
Cs-137	2001/03/01	9 +- 0	9 +- 2	9 +- 1	0.98
	2001/09/01	17 +- 1	18 +- 3	17 +- 1	1.01
Mn-54	2001/03/01	7 +- 0	7 +- 1	7 +- 0	1.07
	2001/09/01	81 +- 5	87 +- 15	84 +- 5	1.03
Sr-90	2001/03/01	7 +- 0	7 +- 2	6 +- 0	0.82
	2001/09/01	3 +- 0	4 +- 1	3 +- 0	0.89

*: Excluding those results significantly different from the population mean.

Table 7.10: USDOE Soil

Analysis	Sample Date	USDOE	*All Participants (Bq/kg ± 2 sigma)	NB Power (Bq/kg ± 2 sigma)	NB Power/ USDOE (ratio)
Cs-137	2001/03/01	1740 +- 90	1778 +- 300	1630 +- 94	0.94
	2001/09/01	612 +- 31	618 +- 90	530 +- 31	0.87
K-40	2001/03/01	468 +- 25	484 +- 95	465 +- 42	0.99
	2001/09/01	623 +- 33	628 +- 99	582 +- 49	0.93

*: Excluding those results significantly different from the population mean.

Table 7.11: USDOE Vegetation

Analysis	Sample Date	USDOE	*All Participants (Bq/kg ± 2 sigma)	NB Power (Bq/kg ± 2 sigma)	NB Power/ USDOE (ratio)
Co-60	2001/03/01	30 +- 1	32 +- 6	33 +- 3	1.09
	2001/09/01	35 +- 1	37 +- 8	36 +- 3	1.01
Cs-137	2001/03/01	842 +- 42	880 +- 157	909 +- 55	1.08
	2001/09/01	1030 +- 52	1090 +- 218	1050 +- 63	1.02
K-40	2001/03/01	603 +- 32	646 +- 138	803 +- 76	1.33
	2001/09/01	899 +- 48	956 +- 203	979 +- 87	1.09

*: Excluding those results significantly different from the population mean.

Table 7.12: RPB Urine

Analysis	Sample Date	RPB	*All Participants (Bq/L ± 2 sigma)	NB Power (Bq/L ± 2 sigma)	NB Power/ RPB
C-14 #1	2001/05/17	3640	3560 +- 476	3440 +- 100	0.95
C-14 #2	2001/05/17	17700	17400 +- 1670	16700 +- 291	0.94
C-14 #3	2001/05/17	280000	269000 +- 25300	255000 +- 4680	0.91
Co-60	2001/10/01	174 +- 52	175 +- 14	165 +- 8	0.95
Cs-137	2001/10/01	209 +- 1	207 +- 21	193 +- 13	0.92
H-3 #1	2001/04/26	12000	11100 +- 2030	10900 +- 84	0.91
H-3 #2	2001/04/26	450000	403000 +- 84200	375000 +- 6270	0.83
H-3 #3	2001/04/26	1E+7	9E+6 +- 2E+6	9E+6 +- 8E+4	0.91

*: Excluding those results significantly different from the population mean.

Table 7.08: USDOE Water

Analysis	Sample Date	USDOE	*All Participants (Bq/L ± 2 sigma)	NB Power (Bq/L ± 2 sigma)	NB Power/ USDOE (ratio)
ALPHA	2001/03/01	1900 +- 190	1832 +- 387	1590 +- 85	0.84
	2001/09/01	1150 +- 115	1129 +- 309	871 +- 54	0.76
BETA	2001/03/01	1300 +- 100	1377 +- 414	1510 +- 77	1.16
	2001/09/01	7970 +- 800	7659 +- 1640	7440 +- 308	0.93
Co-60	2001/03/01	98 +- 4	101 +- 9	91 +- 5	0.93
	2001/09/01	209 +- 8	209 +- 22	192 +- 10	0.92
Cs-137	2001/03/01	73 +- 4	76 +- 8	66 +- 5	0.90
	2001/09/01	45 +- 2	47 +- 5	45 +- 4	0.99
H-3	2001/03/01	79 +- 2	89 +- 36	74 +- 8	0.93
	2001/09/01	207 +- 3	217 +- 60	203 +- 10	0.98
Sr-90	2001/03/01	4 +- 0	4 +- 1	4 +- 0	0.82
	2001/09/01	4 +- 0	4 +- 1	1 +- 0	0.39 FAIL

*: Excluding those results significantly different from the population mean.

Table 7.09: USDOE Air Filter

Analysis	Sample Date	USDOE	*All Participants (Bq/filter ± 2 sigma)	NB Power (Bq/filter ± 2 sigma)	NB Power/ USDOE (ratio)
ALPHA	2001/03/01	4 +- 0	4 +- 1	4 +- 0	0.96
	2001/09/01	5 +- 1	5 +- 2	5 +- 0	1.01
BETA	2001/03/01	3 +- 0	3 +- 1	3 +- 0	1.16
	2001/09/01	13 +- 1	12 +- 2	12 +- 0	0.95
Co-60	2001/03/01	19 +- 1	19 +- 2	19 +- 1	0.97
	2001/09/01	18 +- 0	18 +- 3	17 +- 1	0.96
Cs-134	2001/03/01	3 +- 0	3 +- 1	3 +- 0	0.95
	2001/09/01	13 +- 0	13 +- 3	13 +- 1	0.97
Cs-137	2001/03/01	9 +- 0	9 +- 2	9 +- 1	0.98
	2001/09/01	17 +- 1	18 +- 3	17 +- 1	1.01
Mn-54	2001/03/01	7 +- 0	7 +- 1	7 +- 0	1.07
	2001/09/01	81 +- 5	87 +- 15	84 +- 5	1.03
Sr-90	2001/03/01	7 +- 0	7 +- 2	6 +- 0	0.82
	2001/09/01	3 +- 0	4 +- 1	3 +- 0	0.89

*: Excluding those results significantly different from the population mean.

Table 7.10: USDOE Soil

Analysis	Sample Date	USDOE	*All Participants (Bq/kg ± 2 sigma)	NB Power (Bq/kg ± 2 sigma)	NB Power/ USDOE (ratio)
Cs-137	2001/03/01	1740 +- 90	1778 +- 300	1630 +- 94	0.94
	2001/09/01	612 +- 31	618 +- 90	530 +- 31	0.87
K-40	2001/03/01	468 +- 25	484 +- 95	465 +- 42	0.99
	2001/09/01	623 +- 33	628 +- 99	582 +- 49	0.93

*: Excluding those results significantly different from the population mean.

Table 7.11: USDOE Vegetation

Analysis	Sample Date	USDOE	*All Participants (Bq/kg ± 2 sigma)	NB Power (Bq/kg ± 2 sigma)	NB Power/ USDOE (ratio)
Co-60	2001/03/01	30 +- 1	32 +- 6	33 +- 3	1.09
	2001/09/01	35 +- 1	37 +- 8	36 +- 3	1.01
Cs-137	2001/03/01	842 +- 42	880 +- 157	909 +- 55	1.08
	2001/09/01	1030 +- 52	1090 +- 218	1050 +- 63	1.02
K-40	2001/03/01	603 +- 32	646 +- 138	803 +- 76	1.33
	2001/09/01	899 +- 48	956 +- 203	979 +- 87	1.09

*: Excluding those results significantly different from the population mean.

Table 7.12: RPB Urine

Analysis	Sample Date	RPB	*All Participants (Bq/L ± 2 sigma)	NB Power (Bq/L ± 2 sigma)	NB Power/ RPB
C-14 #1	2001/05/17	3640	3560 +- 476	3440 +- 100	0.95
C-14 #2	2001/05/17	17700	17400 +- 1670	16700 +- 291	0.94
C-14 #3	2001/05/17	280000	269000 +- 25300	255000 +- 4680	0.91
Co-60	2001/10/01	174 +- 52	175 +- 14	165 +- 8	0.95
Cs-137	2001/10/01	209 +- 1	207 +- 21	193 +- 13	0.92
H-3 #1	2001/04/26	12000	11100 +- 2030	10900 +- 84	0.91
H-3 #2	2001/04/26	450000	403000 +- 84200	375000 +- 6270	0.83
H-3 #3	2001/04/26	1E+7	9E+6 +- 2E+6	9E+6 +- 8E+4	0.91

*: Excluding those results significantly different from the population mean.

Table 7.13: IAEA Soil

Analysis	Sample Date	IAEA	NB Power (Bq/kg ± 2 sigma)	NB Power/ IAEA (ratio)
Cs-137	2001/02/14	54 +- 3	46 +- 3	0.85 FAIL
	2001/07/25	54 +- 3	45 +- 5	0.84 FAIL

Table 7.14: IAEA Vegetation

Analysis	Sample Date	IAEA	NB Power (Bq/kg ± 2 sigma)	NB Power/ IAEA (ratio)
Cs-134	2001/12/20	1170 +- 24	1850 +- 291	1.58 FAIL
Cs-137	2001/06/14	264 +- 5	266 +- 18	1.01
	2001/12/20	12400 +- 220	15200 +- 1490	1.23 FAIL
K-40	2001/06/14	657 +- 20	718 +- 69	1.09 FAIL
	2001/12/20	432 +- 11	578 +- 64	1.34 FAIL

Table 7.15: IAEA Milk

Analysis	Sample Date	IAEA	NB Power (Bq/kg ± 2 sigma)	NB Power/ IAEA (ratio)
Cs-134	2001/07/19	1360 +- 61	1000 +- 151	0.74 FAIL
Cs-137	2001/07/19	3750 +- 137	2490 +- 145	0.66 FAIL
K-40	2001/07/19	1580 +- 67	1210 +- 86	0.77 FAIL

Table 7.16: NRC Environmental TLD

Analysis	Sample Date	NRC	NB Power (mR ± 2 sigma)	NB Power/ NRC (ratio)
Gamma	2001/07/03	131 +- 0	121 +- 6	0.92
	2001/12/24	123 +- 0	116 +- 8	0.94

Table 7.13: IAEA Soil

Analysis	Sample Date	IAEA	NB Power (Bq/kg ± 2 sigma)	NB Power/ IAEA (ratio)
Cs-137	2001/02/14	54 +- 3	46 +- 3	0.85 FAIL
	2001/07/25	54 +- 3	45 +- 5	0.84 FAIL

Table 7.14: IAEA Vegetation

Analysis	Sample Date	IAEA	NB Power (Bq/kg ± 2 sigma)	NB Power/ IAEA (ratio)
Cs-134	2001/12/20	1170 +- 24	1850 +- 291	1.58 FAIL
Cs-137	2001/06/14	264 +- 5	266 +- 18	1.01
	2001/12/20	12400 +- 220	15200 +- 1490	1.23 FAIL
K-40	2001/06/14	657 +- 20	718 +- 69	1.09 FAIL
	2001/12/20	432 +- 11	578 +- 64	1.34 FAIL

Table 7.15: IAEA Milk

Analysis	Sample Date	IAEA	NB Power (Bq/kg ± 2 sigma)	NB Power/ IAEA (ratio)
Cs-134	2001/07/19	1360 +- 61	1000 +- 151	0.74 FAIL
Cs-137	2001/07/19	3750 +- 137	2490 +- 145	0.66 FAIL
K-40	2001/07/19	1580 +- 67	1210 +- 86	0.77 FAIL

Table 7.16: NRC Environmental TLD

Analysis	Sample Date	NRC	NB Power (mR ± 2 sigma)	NB Power/ NRC (ratio)
Gamma	2001/07/03	131 +- 0	121 +- 6	0.92
	2001/12/24	123 +- 0	116 +- 8	0.94

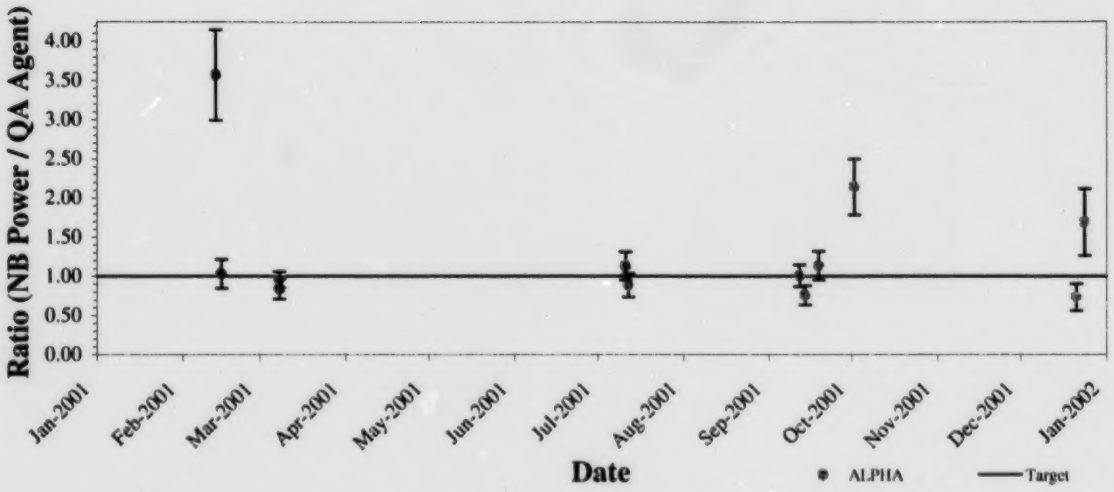

Figure 7.01: Alpha QA Performance (External Agencies)

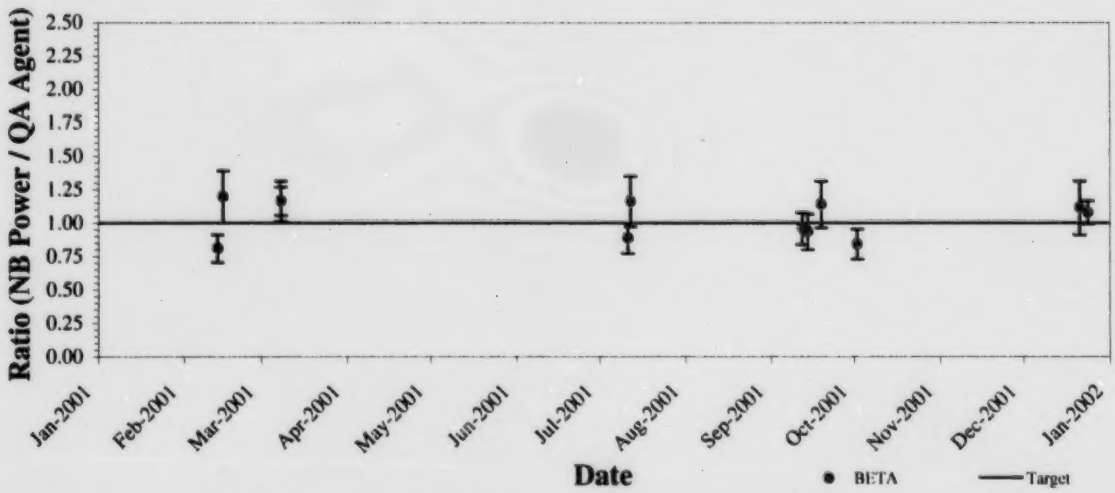

Figure 7.02: Beta QA Performance (External Agencies)

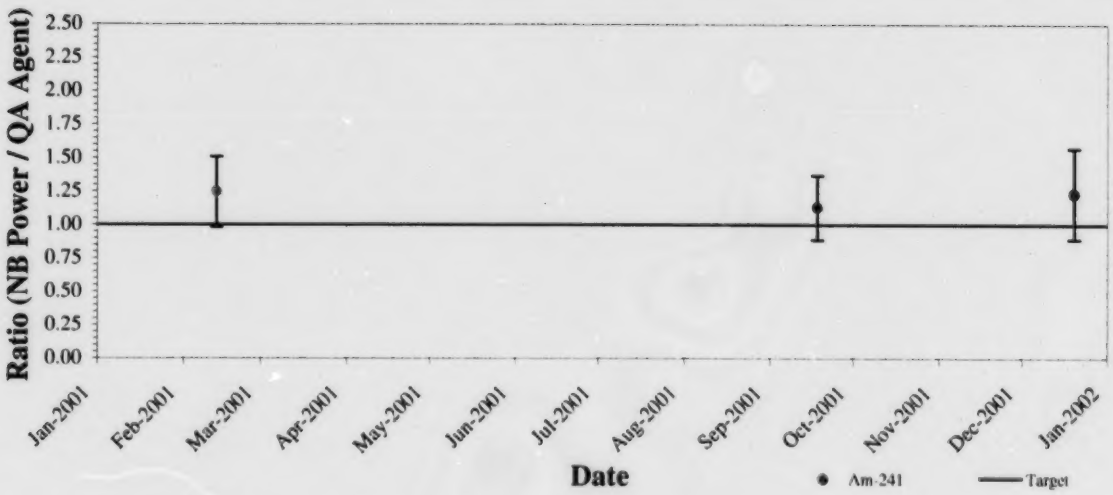

Figure 7.03: Am-241 QA Performance (External Agencies)

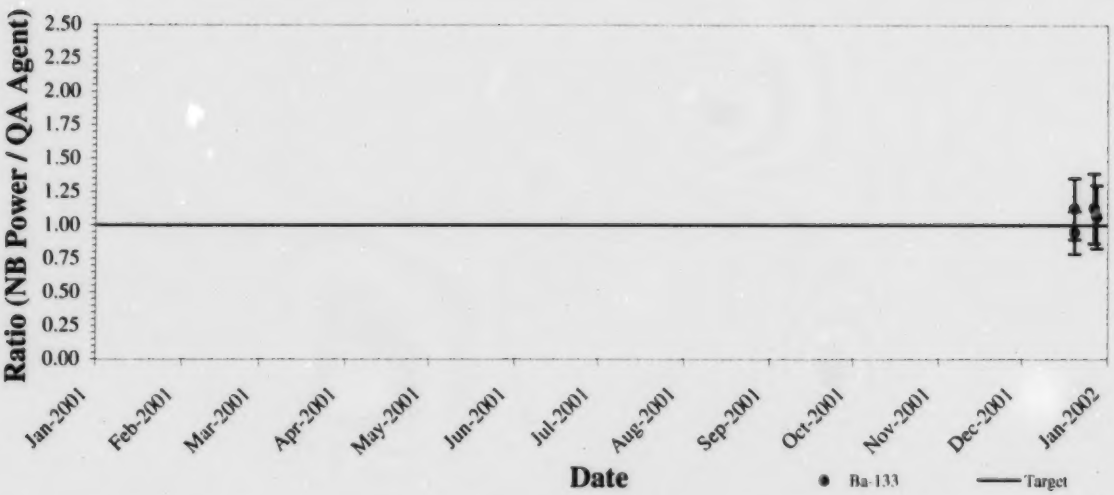

Figure 7.04: Ba-133 QA Performance (External Agencies)

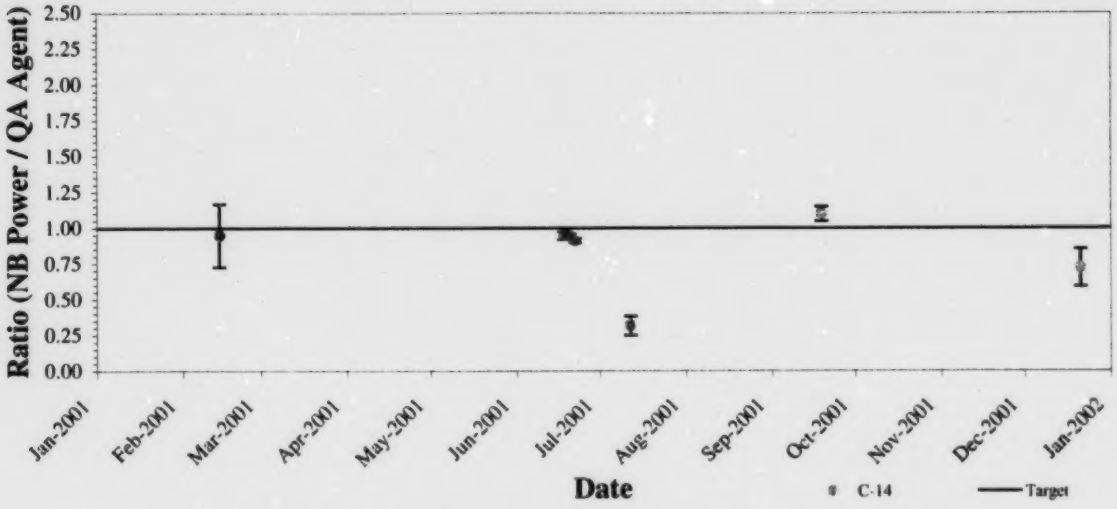

Figure 7.05: C-14 QA Performance (External Agencies)

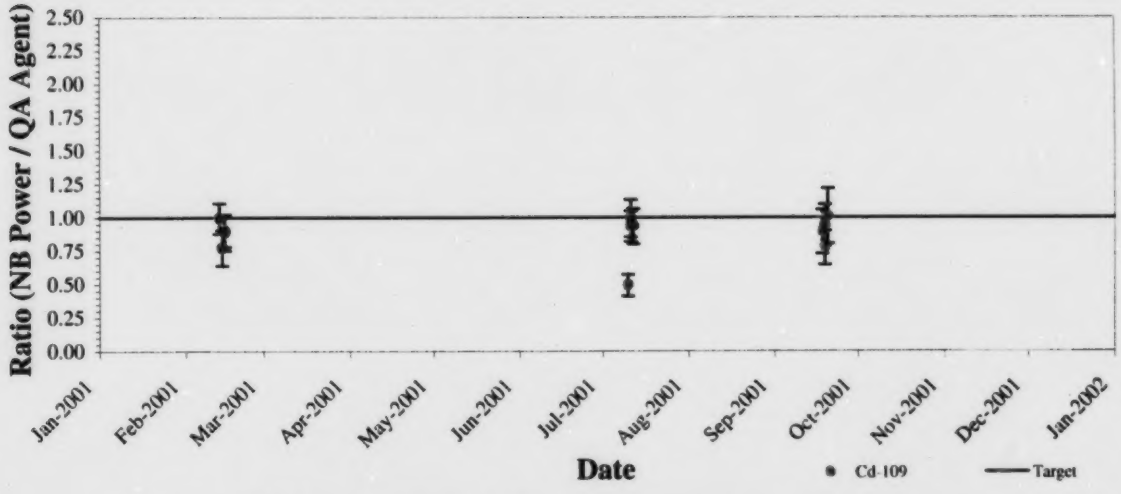

Figure 7.06: Cd-109 QA Performance (External Agencies)

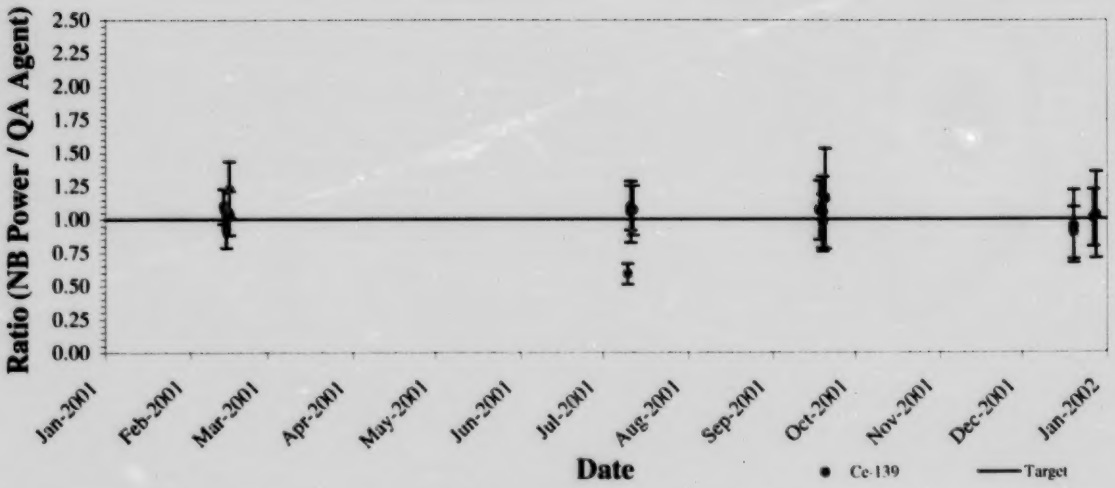

Figure 7.07: Ce-139 QA Performance (External Agencies)

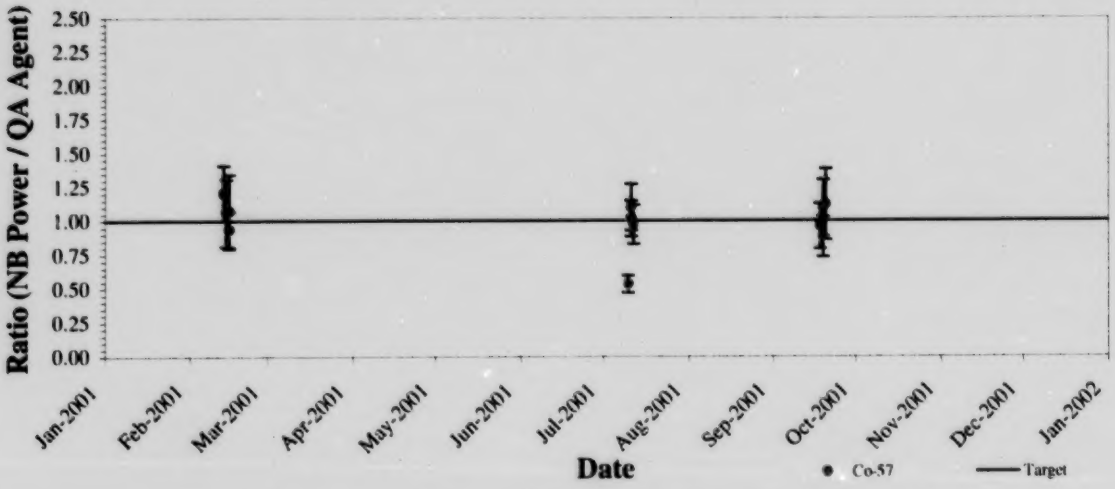

Figure 7.08: Co-57 QA Performance (External Agencies)

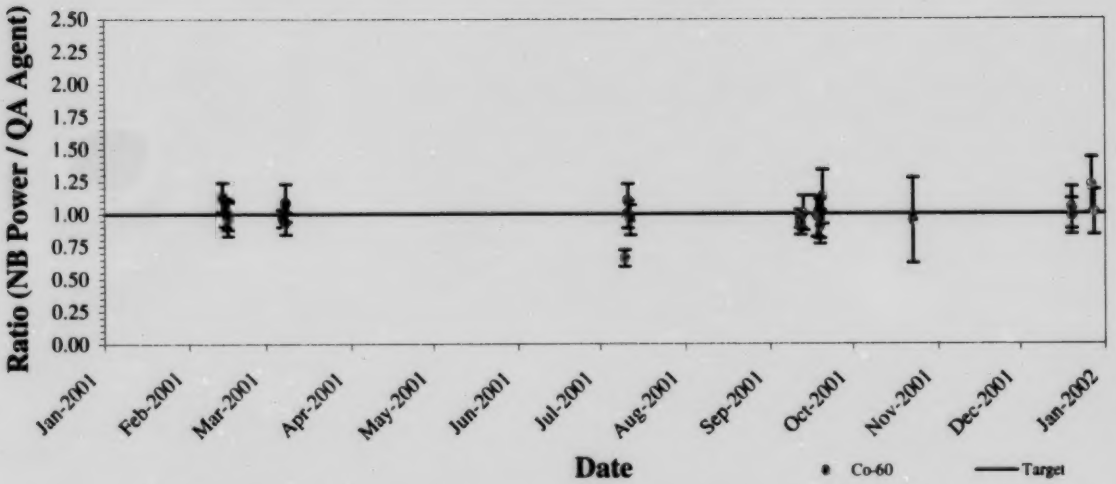

Figure 7.09: Co-60 QA Performance (External Agencies)

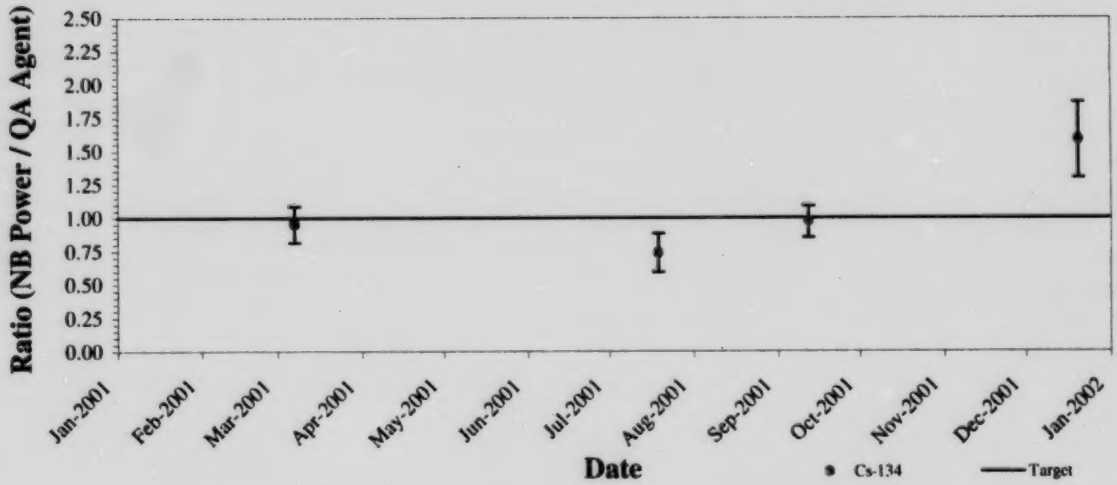

Figure 7.10: Cs-134 QA Performance (External Agencies)

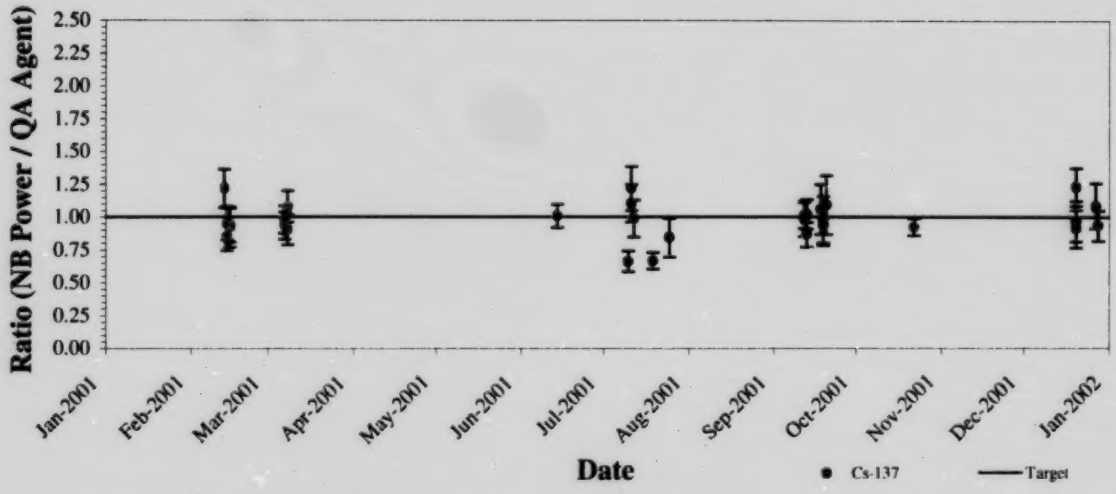

Figure 7.11: Cs-137 QA Performance (External Agencies)

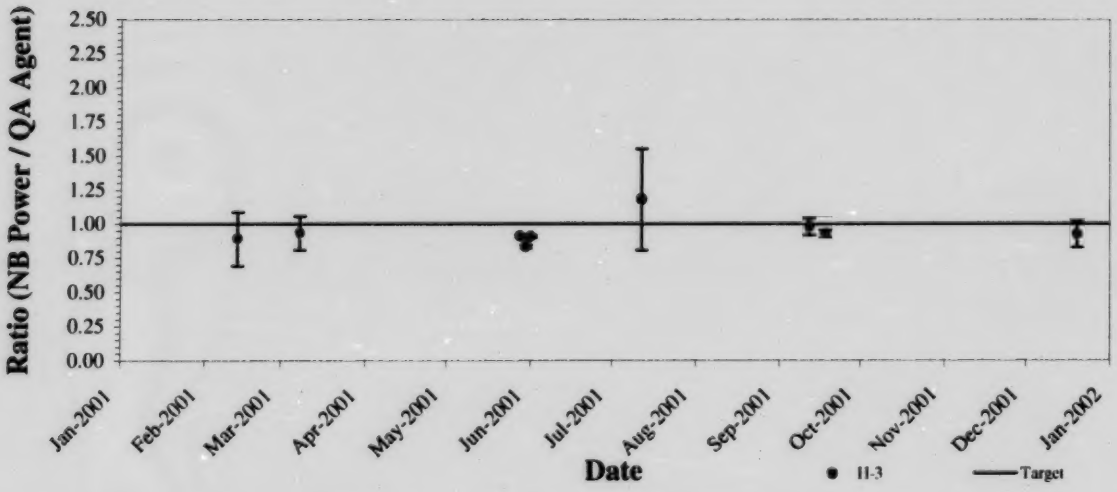

Figure 7.12: H-3 QA Performance (External Agencies)

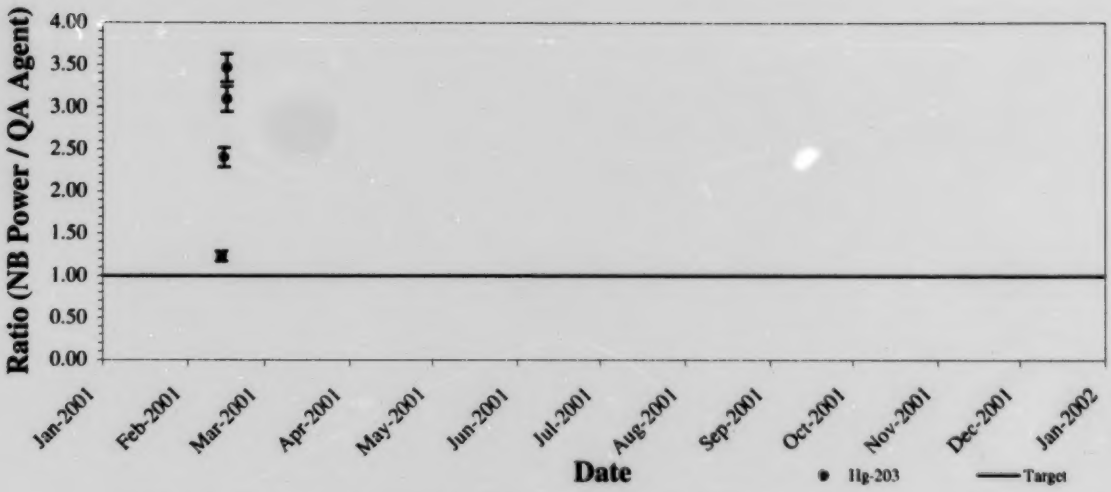

Figure 7.13: Hg-203 QA Performance (External Agencies)

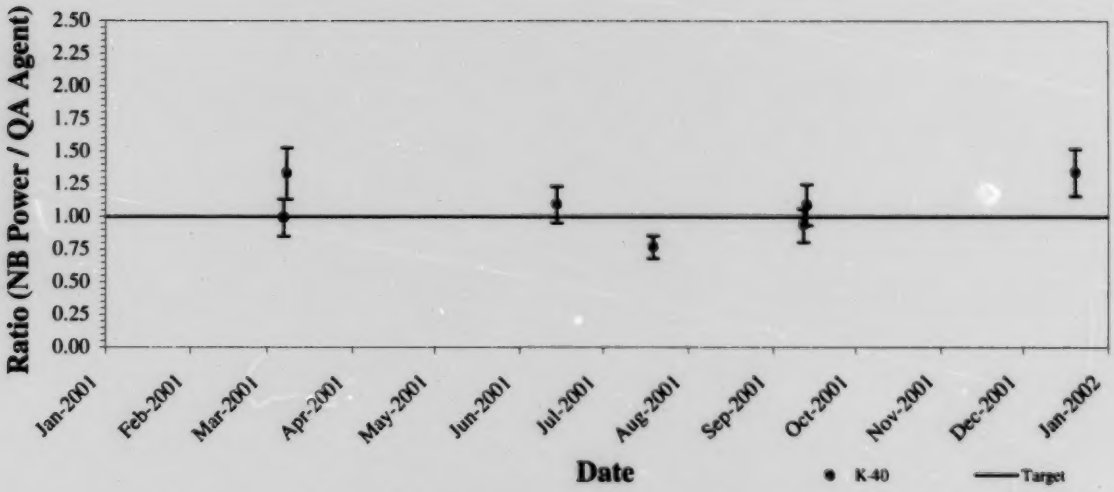

Figure 7.14: K-40 QA Performance (External Agencies)

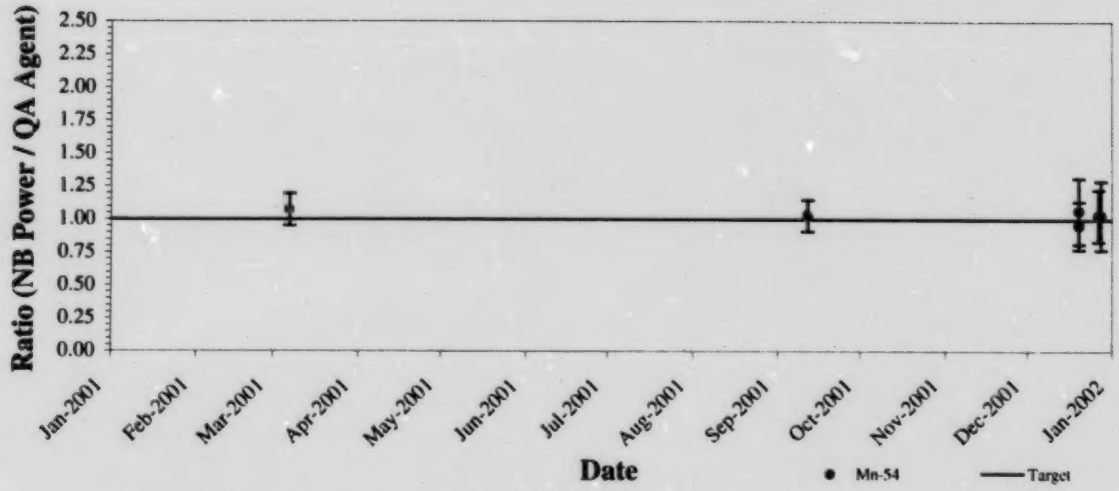

Figure 7.15: Mn-54 QA Performance (External Agencies)

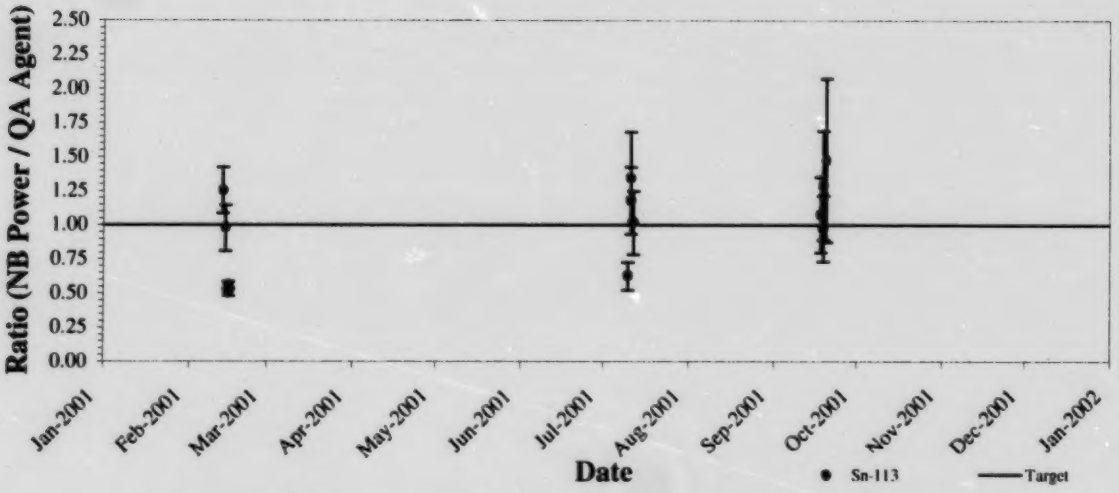

Figure 7.16: Sn-113 QA Performance (External Agencies)

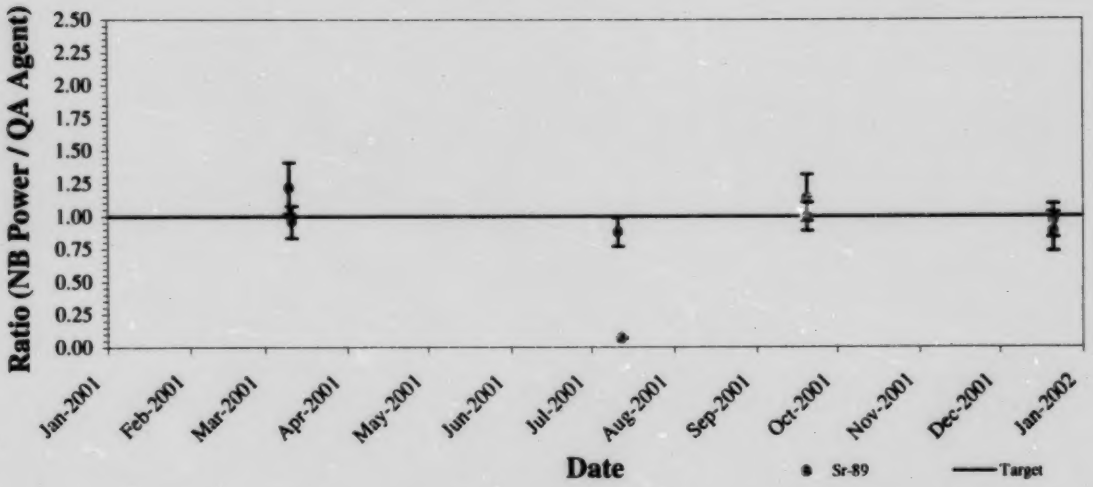

Figure 7.17: Sr-89 QA Performance (External Agencies)

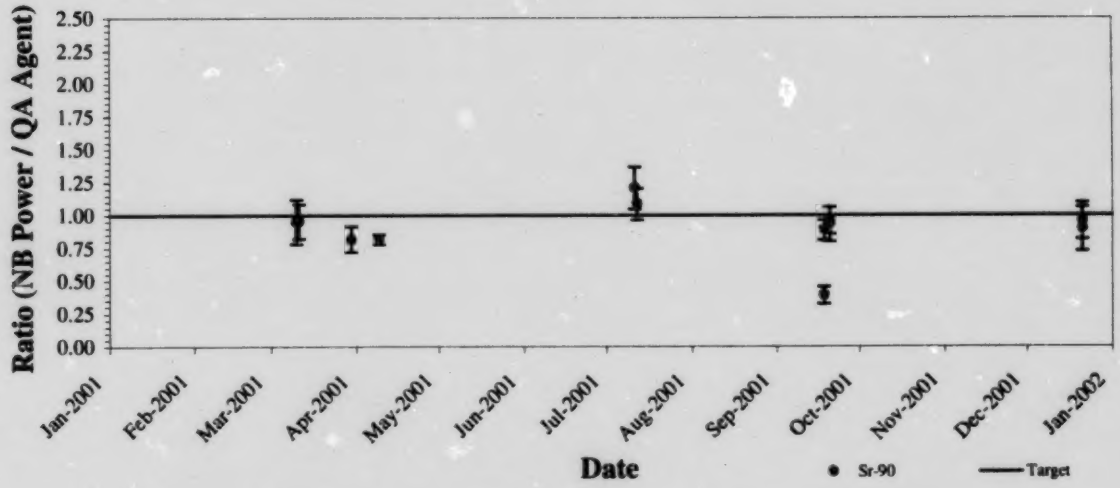

Figure 7.18: Sr-90 QA Performance (External Agencies)

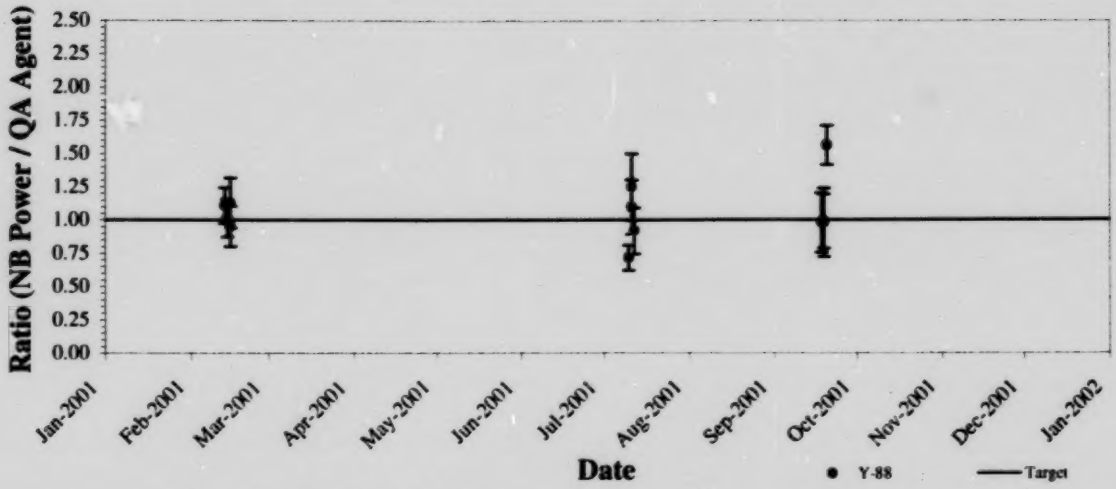

Figure 7.19: Y-88 QA Performance (External Agencies)

7.03 Internal QA

There are four parts to Internal QA:

1) duplicate samples – two samples collected at the same time and analysed separately
2) replicate analyses – two analyses done on the same sample
3) spiked samples – one person spikes a sample and a different person performs the analysis
4) repeated analyses of calibration standards or stock solutions

Duplicate samples and replicate counts are employed as part of the overall quality assurance program. For those media where two samples can be obtained from the same location at the same time, similar analytical results are expected. This approach demonstrates that the samples are representative of the medium in that area. Where duplicate samples are not possible, e.g. air filters, a sample is counted twice to demonstrate reproducibility in the counting system. Results of performance with these samples gives an indication of how representative our samples are, and how reproducible our measurements are.

Tracking of results is done in a spreadsheet and performance is charted. If the range of the ratio (of the two measurements) plus or minus the combined uncertainty (95% confidence interval) includes 1.00, then performance is acceptable. See Table 7.17 for the frequency.

There were 87 samples analysed (205 radionuclide comparisons) in 2001 (see Figures 7.20 to 7.34). Nine of these had failures in one or more of the comparisons (12 comparison failures):

- Be-7 in Airborne Particulates – two failures due to low activity.
- Be-7 in Airborne Iodines - two failures due to low activity.
- Gamma Emitters in LEM Composite – four failures due to the disproportionate presence of suspended solids in a much smaller second sample; two failures due to low activity.
- Alpha in LEM Composite – one failure due to low activity.
- Beta in LEM Composite – one marginal failure (0.99).

Table 7.17: Internal (Duplicate Samples/Replicate Analyses) QA Frequency

Medium	*Duplicate/Replicate*	*Number of Radionuclide Comparisons in 2001*	*Analyses*
Airborne Carbon Dioxide	Replicate analysis (single location)	12	LSC C-14
Airborne Iodines	Replicate count (1 composite set)	32	Gamma
Airborne Particulates	Replicate count	12	Gamma
		24	Alpha/Beta
Garden Vegetables	Replicate count & duplicate sample	3	Gamma
Milk	Duplicate sample	12	Gamma
Parshall Flume	Replicate count	13	LSC H-3
LEM Composite	Replicate count Replicate analysis	46	Gamma
		24	Alpha/Beta
		12	Sr-89,90
Sea Food	Replicate count	2	Gamma
Sediment / Soil	Duplicate sample	9	Gamma
Environmental Gamma	Duplicate sample (single location)	4	TLD

The figures show the analysis date.

Table 7.17: Internal (Duplicate Samples/Replicate Analyses) QA Frequency

Medium	***Duplicate/Replicate***	***Number of Radionuclide Comparisons in 2001***	***Analyses***
Airborne Carbon Dioxide	Replicate analysis (single location)	12	LSC C-14
Airborne Iodines	Replicate count (1 composite set)	32	Gamma
Airborne Particulates	Replicate count	12	Gamma
		24	Alpha/Beta
Garden Vegetables	Replicate count & duplicate sample	3	Gamma
Milk	Duplicate sample	12	Gamma
Parshall Flume	Replicate count	13	LSC H-3
LEM Composite	Replicate count Replicate analysis	46	Gamma
		24	Alpha/Beta
		12	Sr-89,90
Sea Food	Replicate count	2	Gamma
Sediment / Soil	Duplicate sample	9	Gamma
Environmental Gamma	Duplicate sample (single location)	4	TLD

The figures show the analysis date.

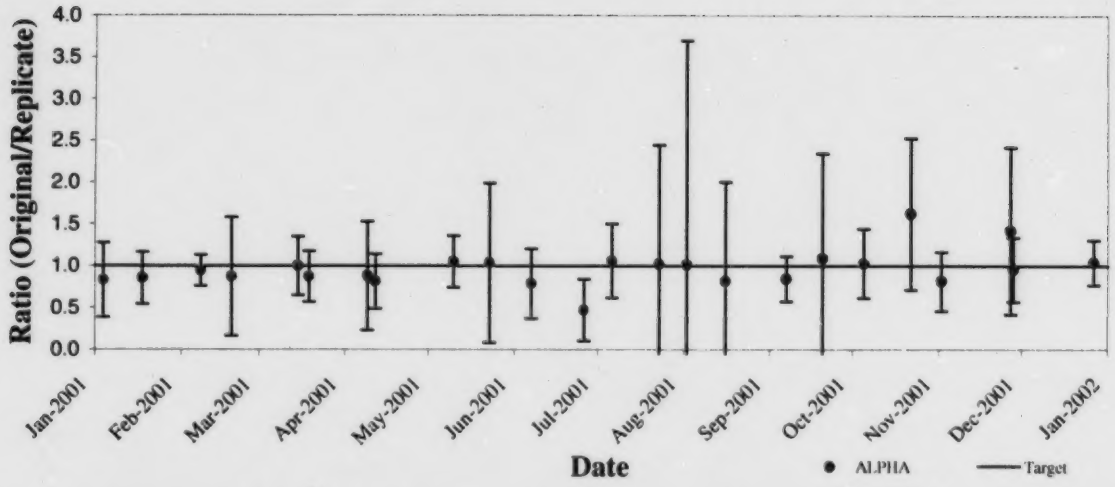

Figure 7.20: Alpha QA Performance (Internal - Duplicate Samples or Replicate Analyses

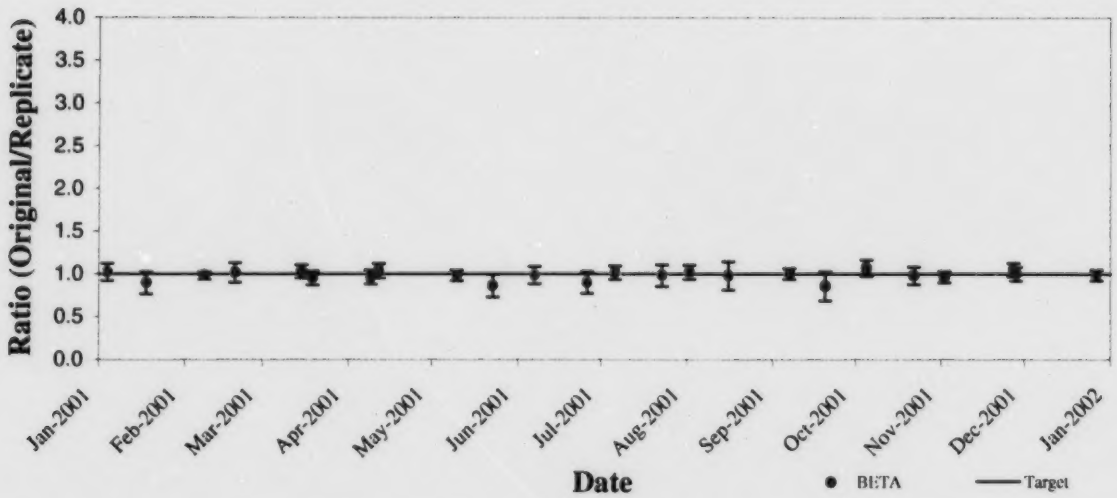

Figure 7.21: Beta QA Performance (Internal - Duplicate Samples or Replicate Analyses)

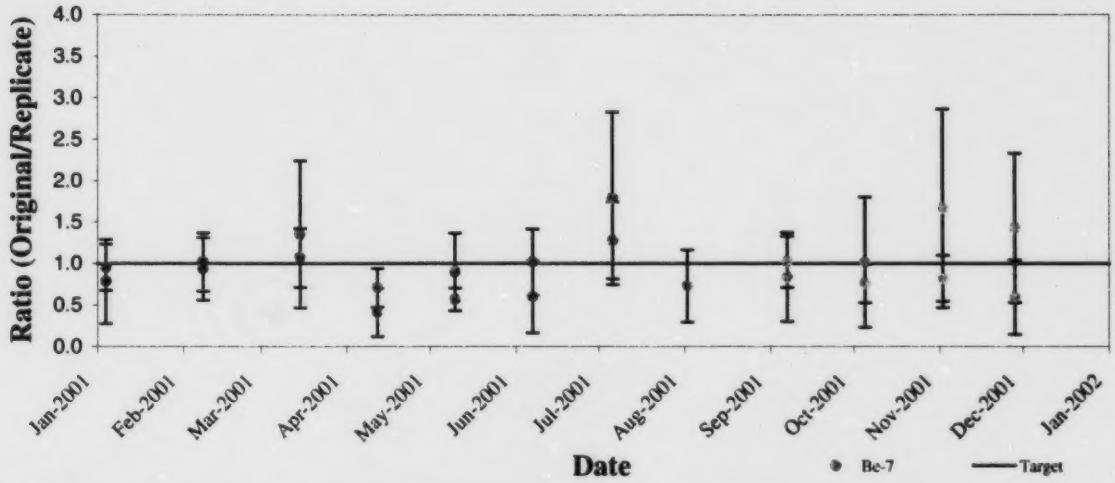

Figure 7.22: Be-7 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

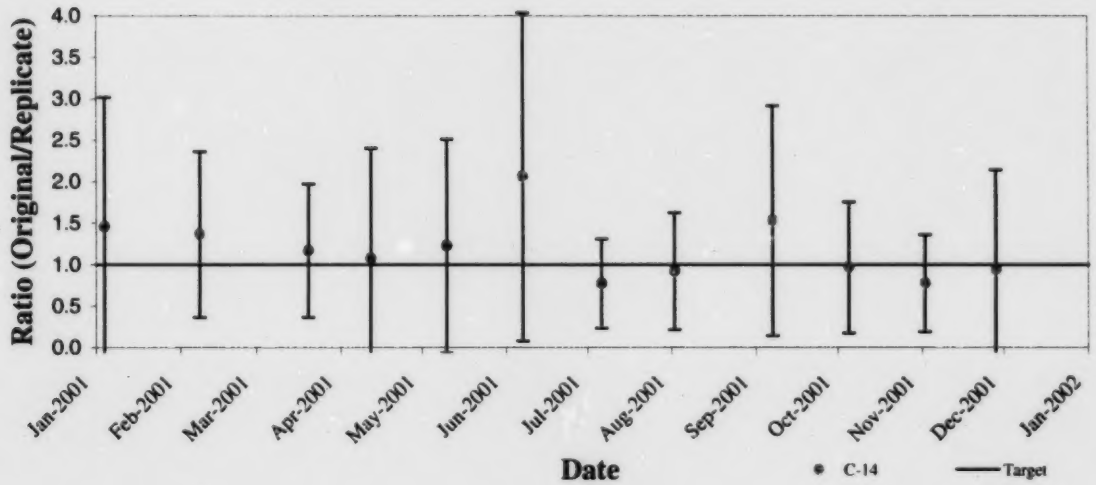

Figure 7.23: C-14 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

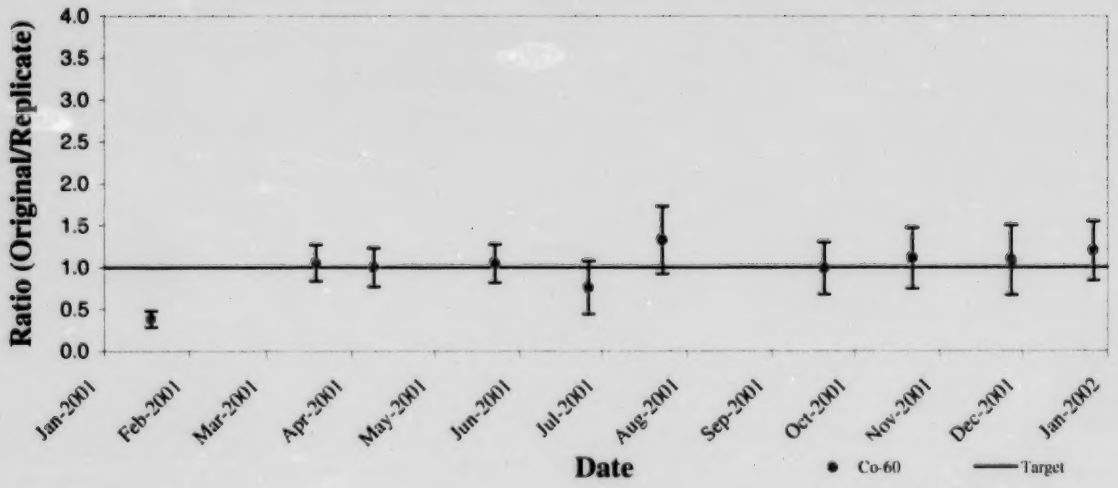

Figure 7.24: Co-60 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

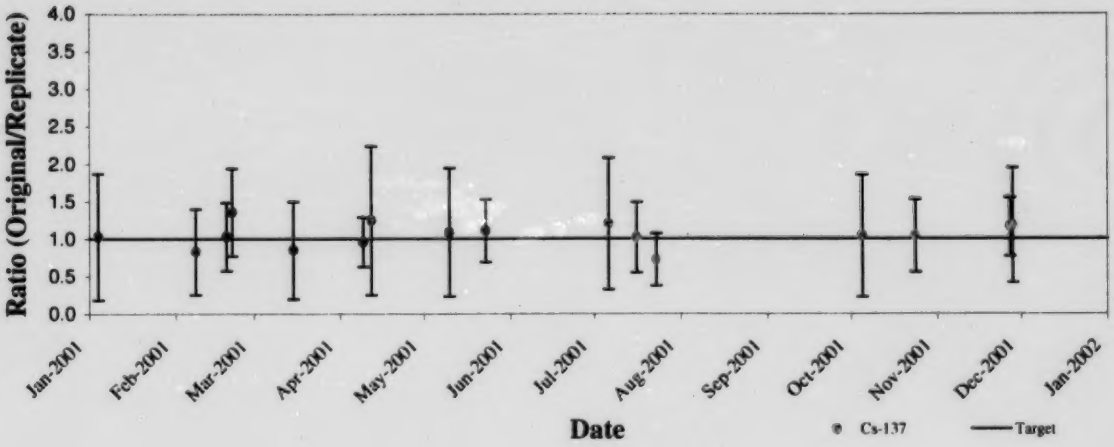

Figure 7.25: Cs-137 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

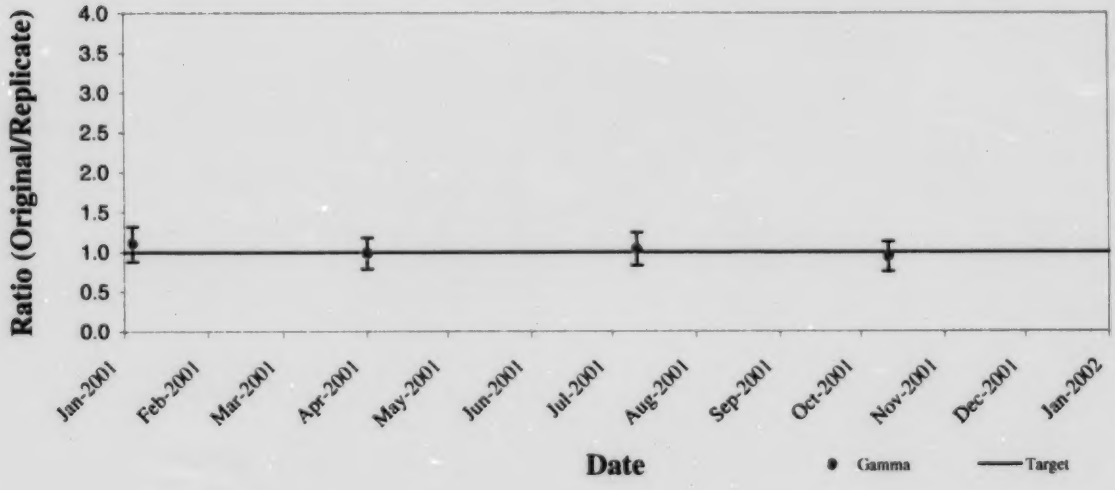

Figure 7.26: TLD QA Performance (Internal - Duplicate Samples or Replicate Analyses)

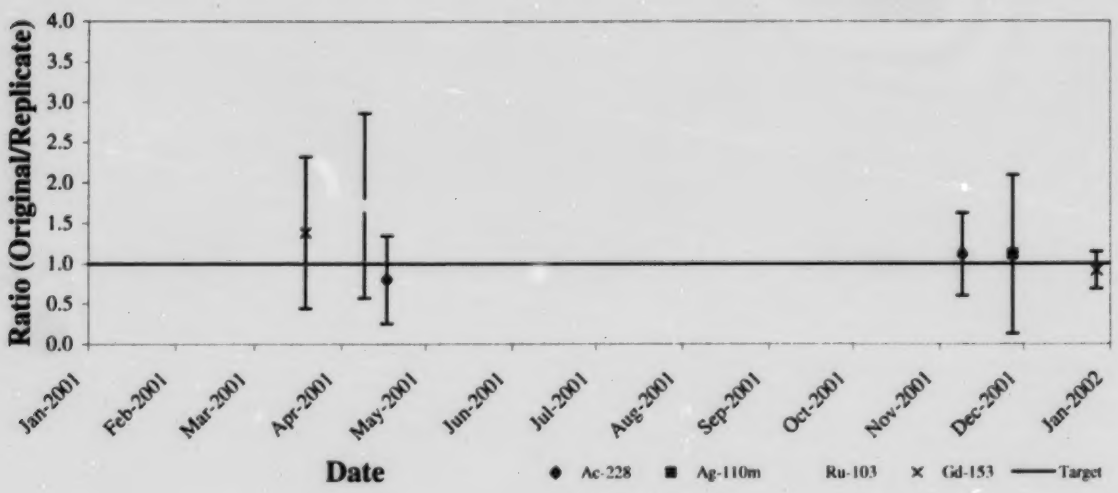

Figure 7.27: Ac-228, Ag-110m, Ru-103, and Gd-153 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

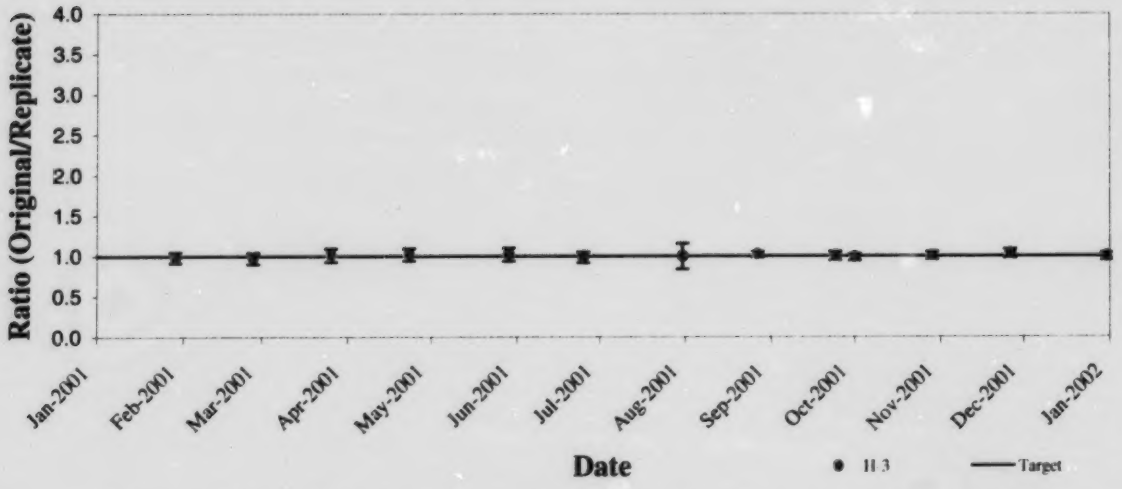

Figure 7.28: H-3 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

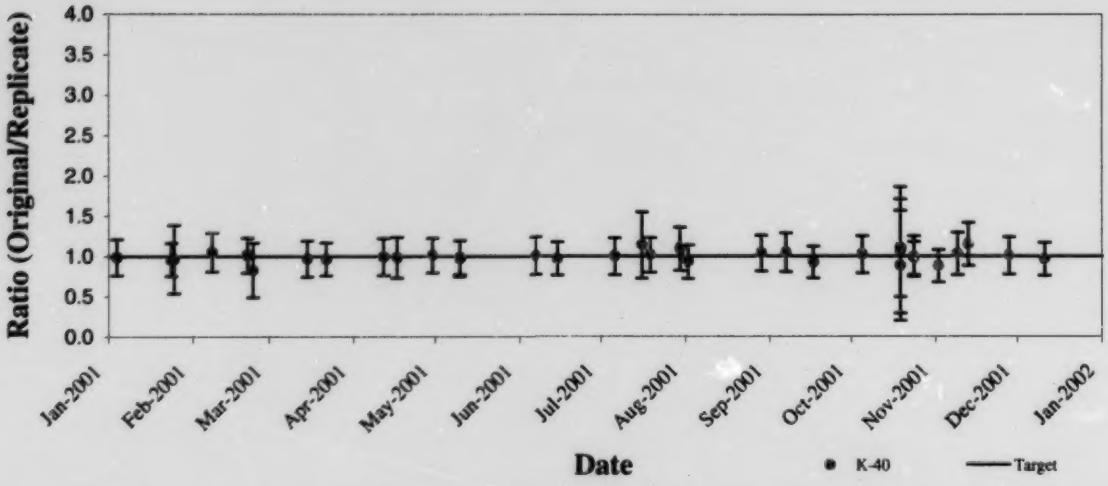

Figure 7.29: K-40 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

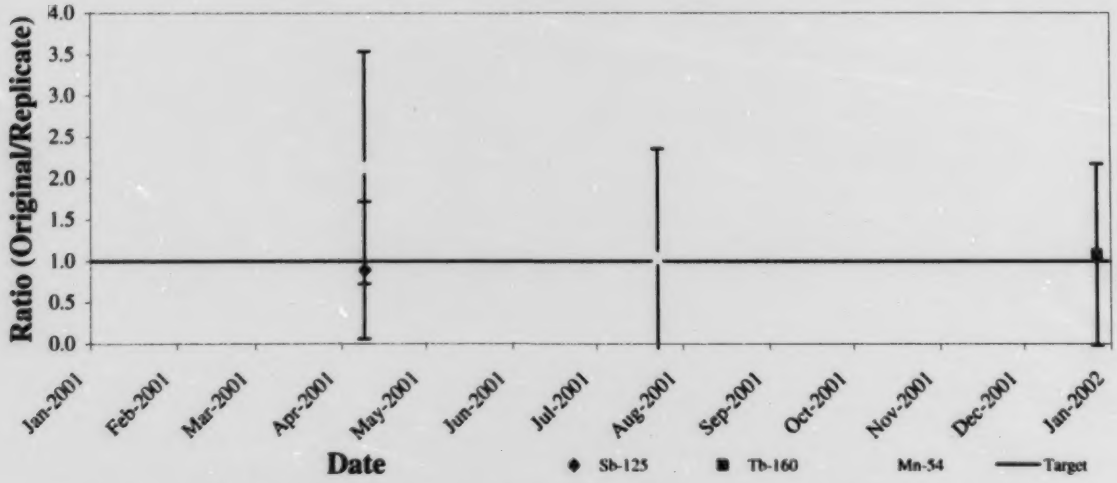

Figure 7.30: Sb-125, Tb-160, and Mn-54 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

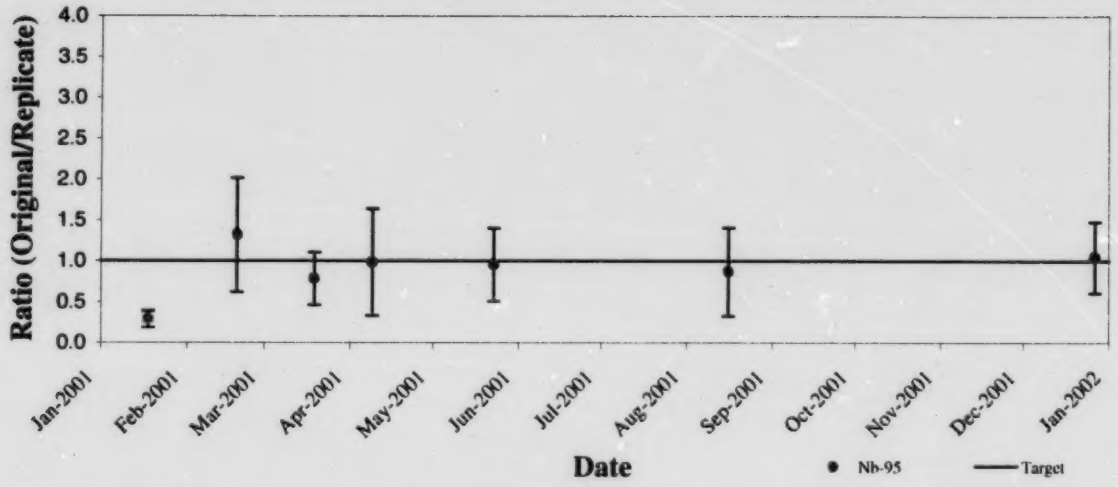

Figure 7.31: Nb-95 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

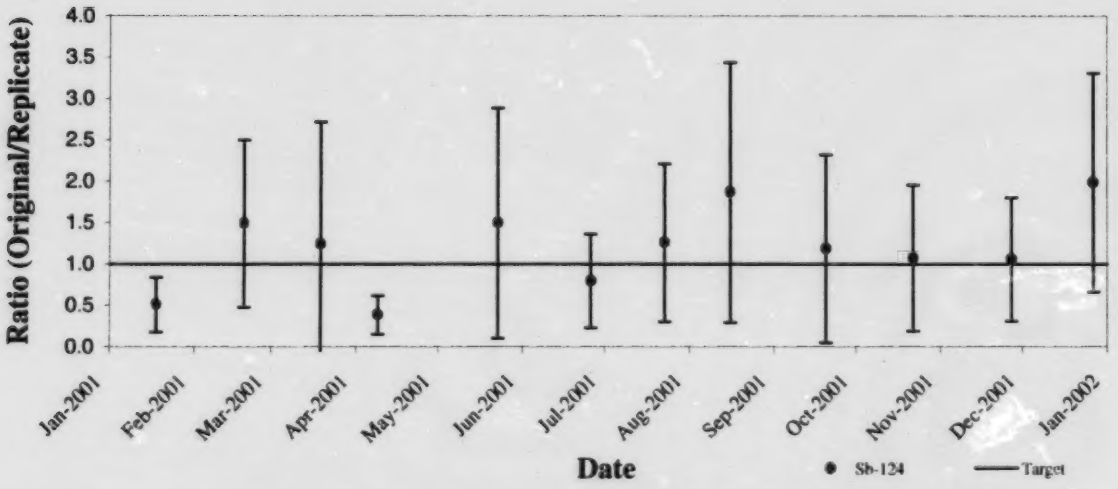

Figure 7.32: Sb-124 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

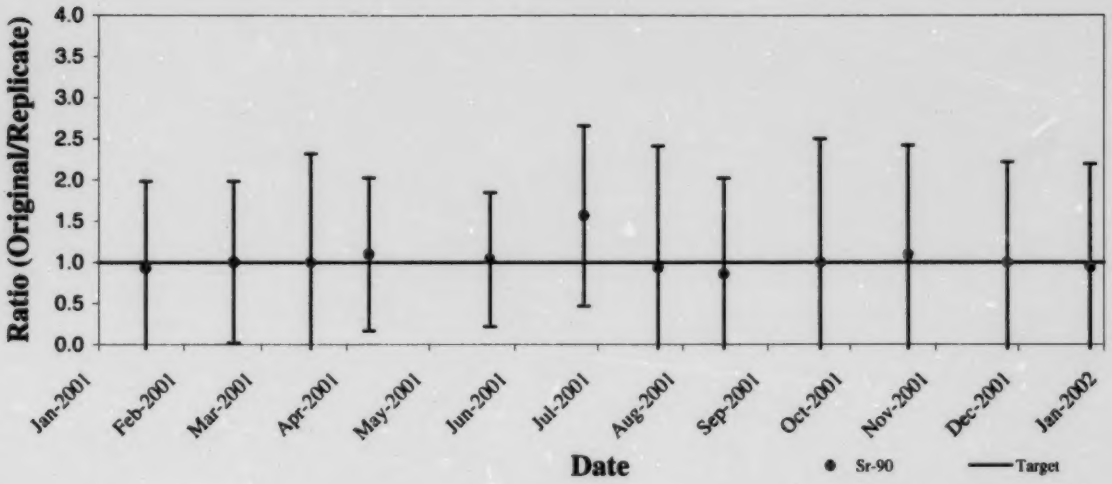

Figure 7.33: Sr-90 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

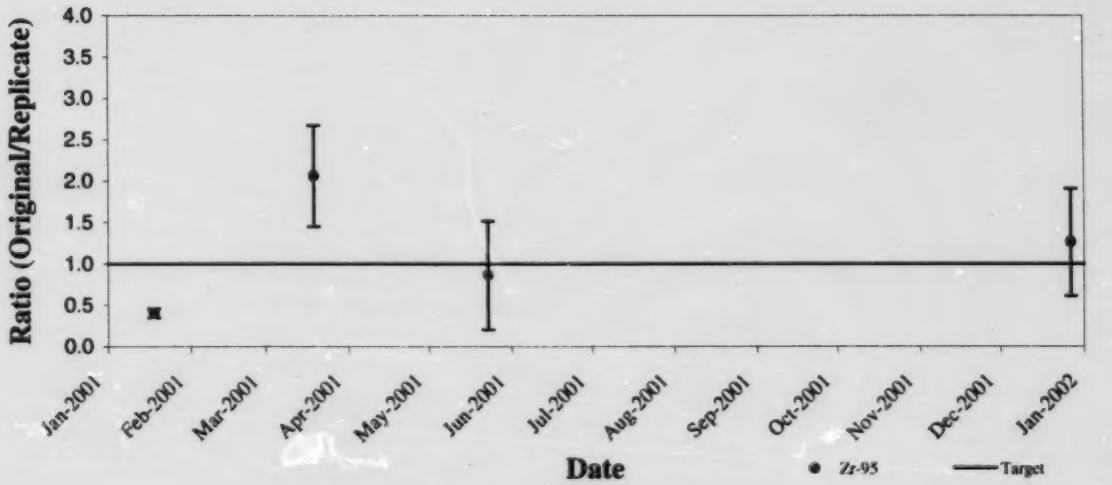

Figure 7.34: Zr-95 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

Spiked samples are also employed as part of the overall quality assurance program in support of the environmental monitoring program. Similar to External QA, one member of the lab staff spikes a sample and a different person analyses the sample. Results of performance with these samples give an indication of the quality of measurements. Tracking of results is done in a spreadsheet and performance is charted. Acceptable performance is defined as results within ± 10% of the expected value. See Table 7.18 for the frequency.

There were 166 samples spiked in 2001 for a total of 190 radionuclide evaluations (see Figures 7.35 to 7.44). There were 39 evaluation failures. If the criteria were relaxed to ± 25% of the expected value, then only four failures occurred (two alpha in water, one alpha on filter and one Co-60 in soil). Considering the uncertainties, the ±10% criterion was too restrictive. This type of QA will be discontinued in 2002 and replaced with more external QA samples.

The figures show the analysis date.

Table 7.18: Internal (Spikes) Quality Assurance Frequency

Media	*Analysis*	*Number of Evaluations in 2001*
Filters	Gross Alpha/Beta	8
	Gamma	5
	Sr-90	4
Environmental Gamma	TLD	5
Milk	Gamma	2
Soil/Sediment	Gamma	2
Water	Gross Alpha/Beta	8
	H-3	76
	C-14	47
	Gamma	5
	Sr-90	4
Food	Gamma	7
Charcoal Cartridges	Gamma	17

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	H-3	76
	C-14	47
	Gamma	5
	Sr-90	4
Food	Gamma	7
Charcoal Cartridges	Gamma	17

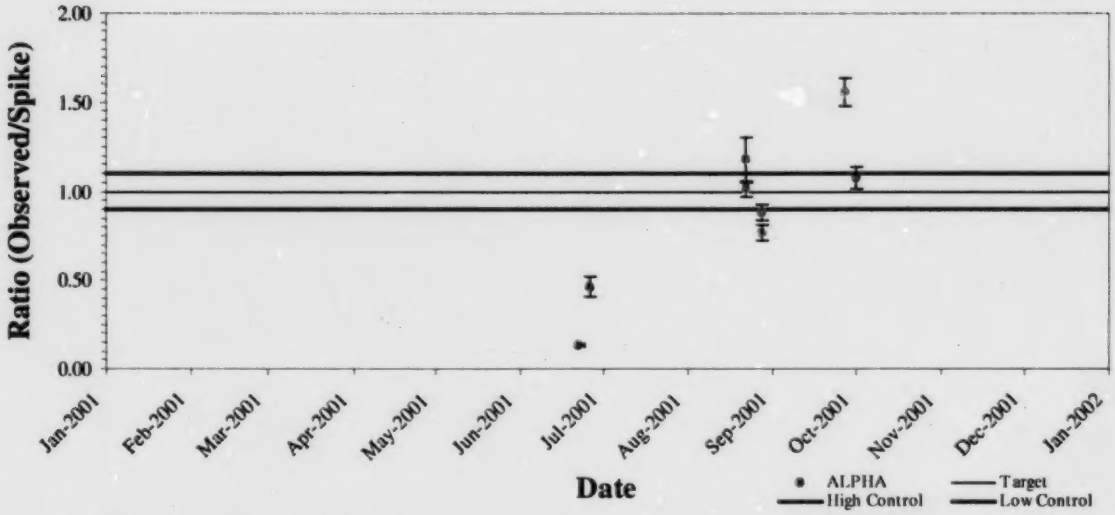

Figure 7.35: Alpha QA Performance (Internal – Spiked Samples)

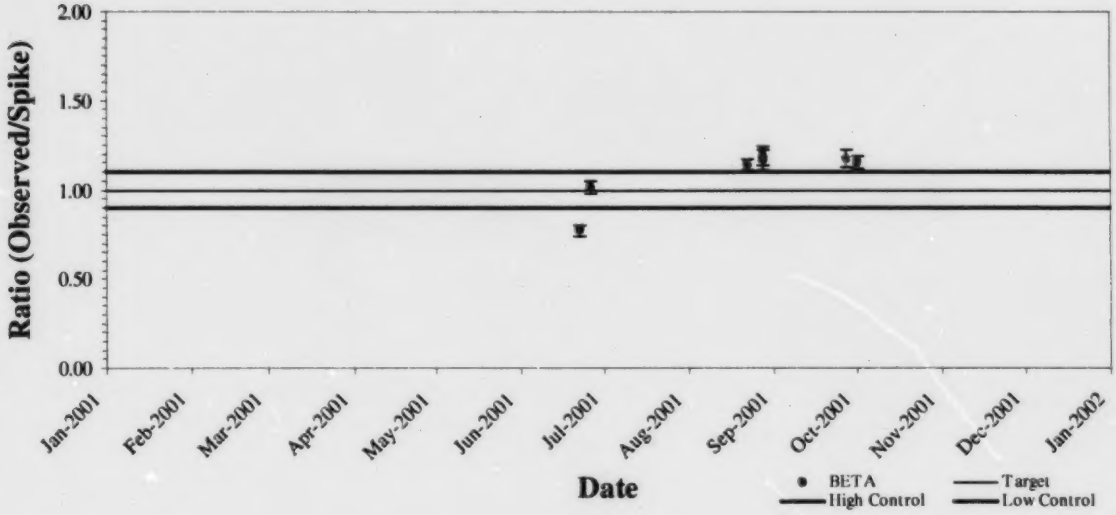

Figure 7.36: Beta QA Performance (Internal – Spiked Samples)

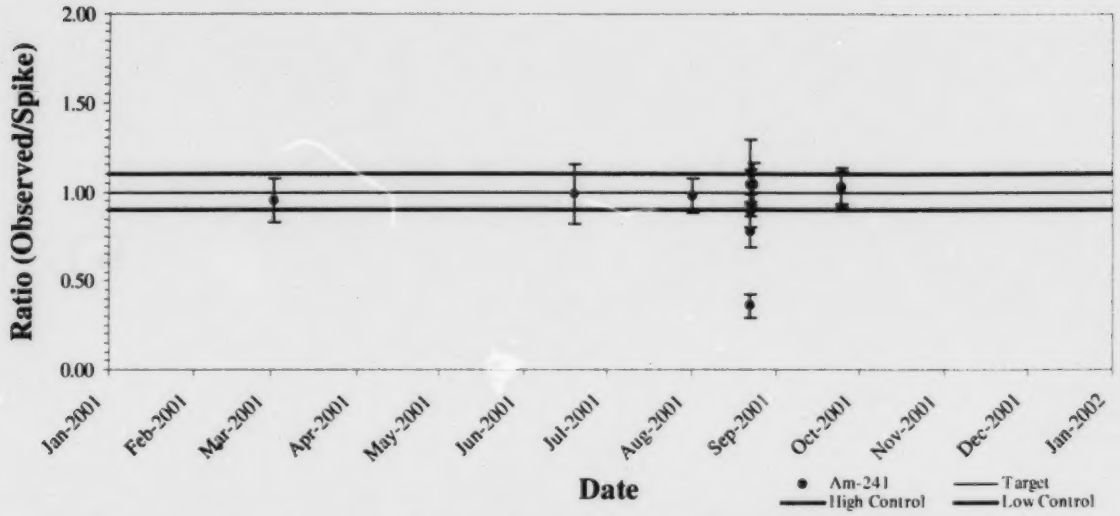

Figure 7.37: Am-241 QA Performance (Internal – Spiked Samples)

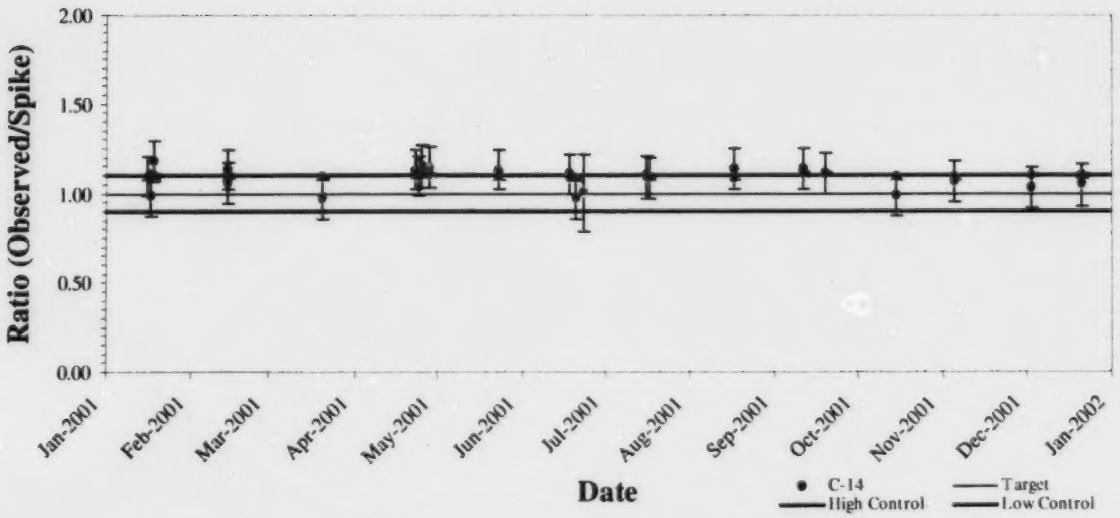

Figure 7.38: C-14 QA Performance (Internal – Spiked Samples)

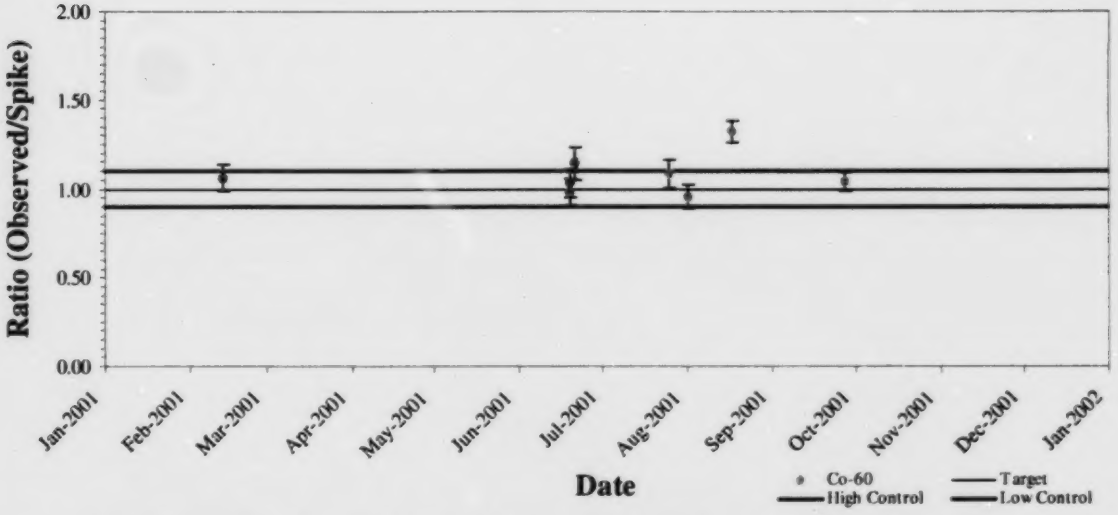

Figure 7.39: Co-60 QA Performance (Internal – Spiked Samples)

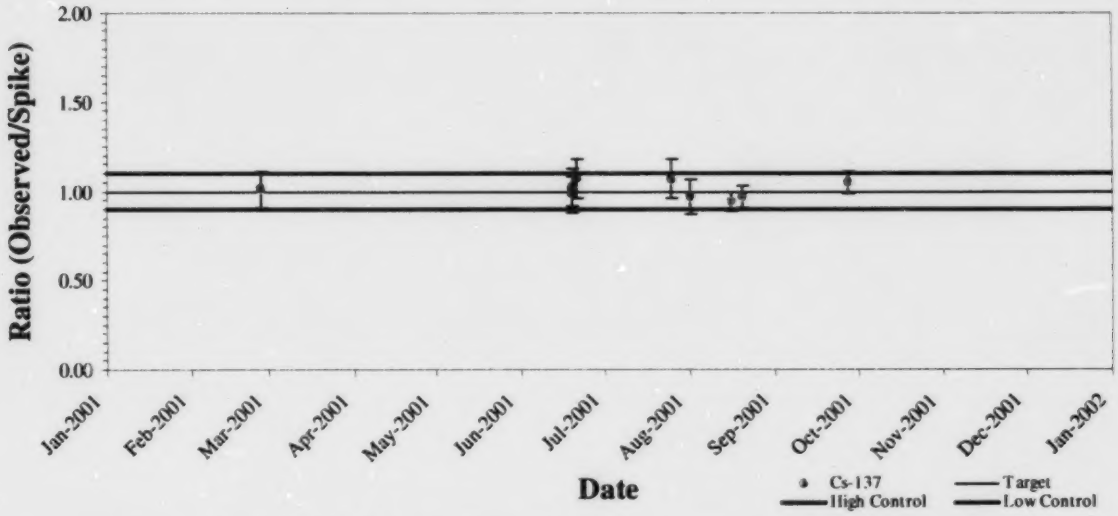

Figure 7.40: Cs-137 QA Performance (Internal – Spiked Samples)

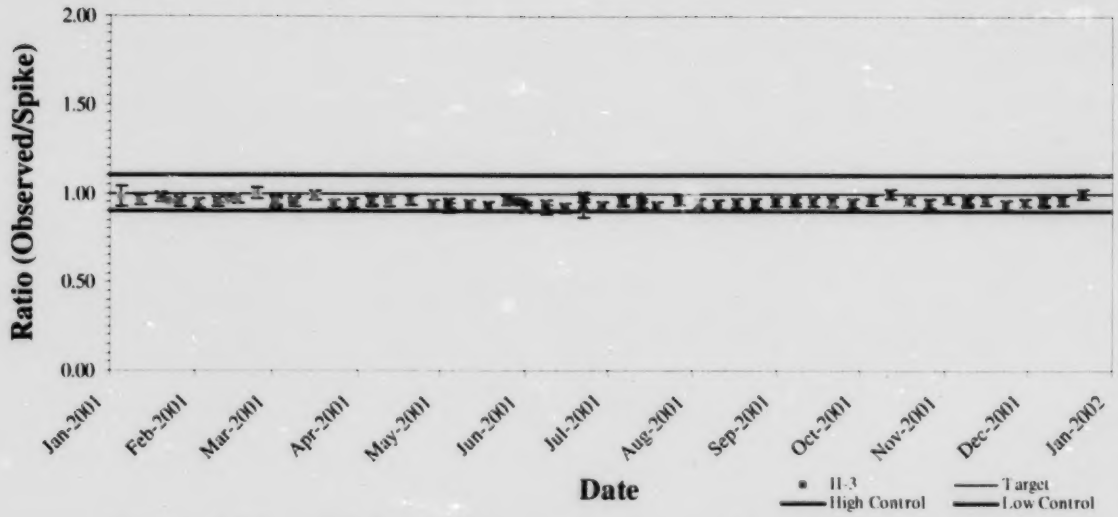

Figure 7.41: H-3 QA Performance (Internal – Spiked Samples)

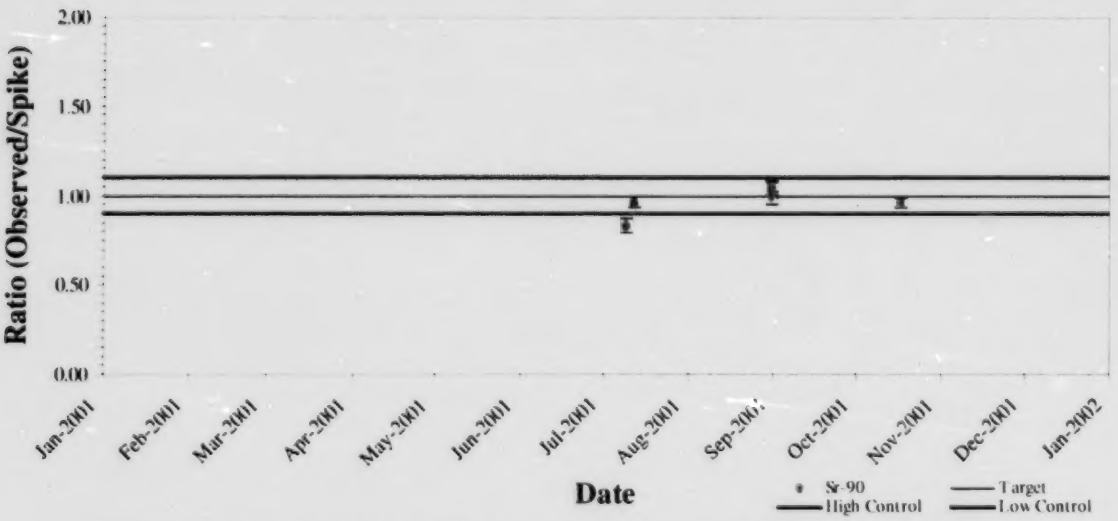

Figure 7.42: Sr-90 QA Performance (Internal – Spiked Samples)

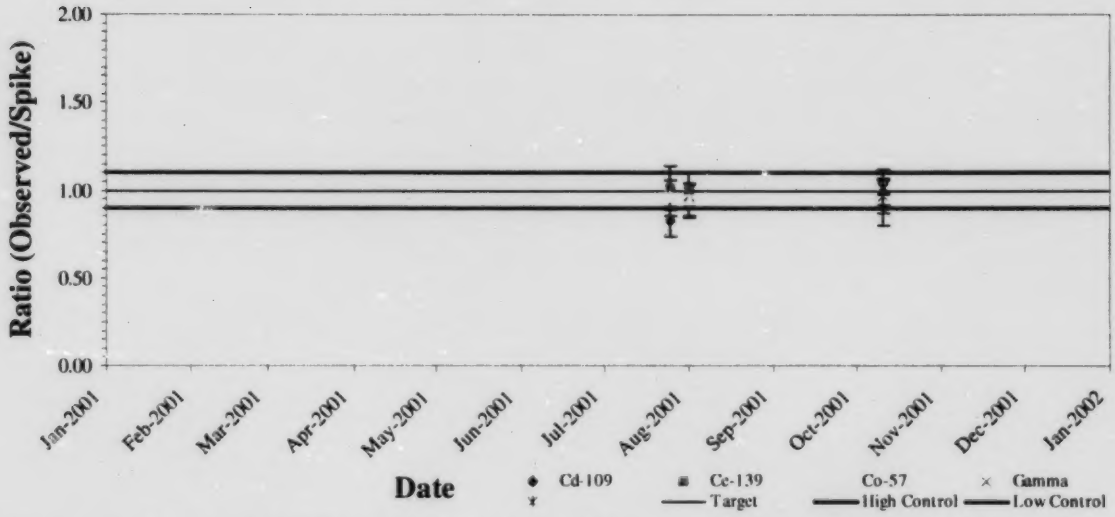

Figure 7.43: Cd-109, Ce-139, Co-57, and Gamma QA Performance (Internal – Spiked Samples)

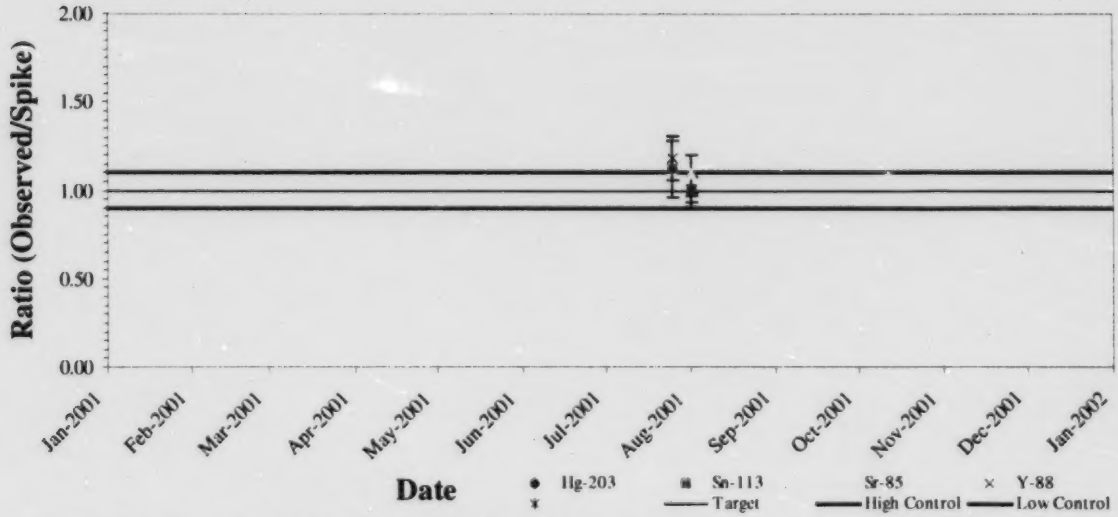

Figure 7.44: Hg-203, Sn-113, Sr-85, and Y-88 QA Performance (Internal – Spiked Samples)

The laboratory also contracted out its services in 2001 for several clients. A calibration standard was run with each set of samples to indicate to the customer the reliability of the results. There were 13 individual radionuclide failures out of 144 tests. These failures occurred when an older standard was analysed (low activity due to decay) and when the very small standards (charcoal cartridge and liquid scintillation vial) were analysed. These results are presented in Figures 7.45 to 7.46. The figures show the analysis date.

As well, stock solutions of C-14 and H-3 and were repeatedly analysed throughout the year. The results are shown in Figures 7.38 and 7.41. These practices provide an extra degree of confidence in the Environmental Program. A slightly negative bias is observed in the H-3 stock solution. This is due to the two to three percent difference between chemical quench and opacity quench. A slightly positive bias is observed in the C-14 stock solution due to evaporation over many years.

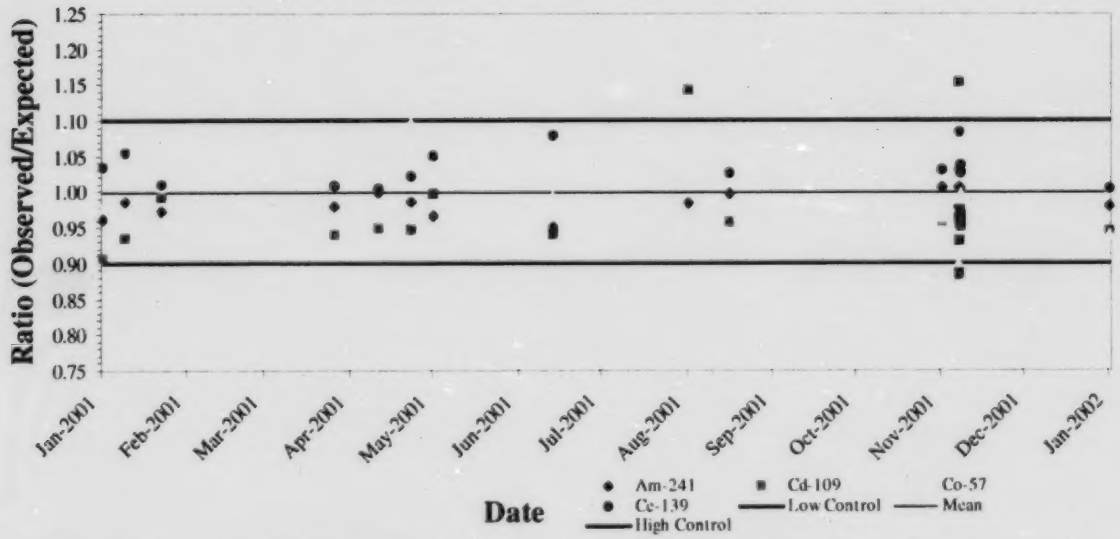

Figure 7.45: Am-241, Cd-109, Ce-139 and Co-57 QA Performance (Internal – Repeated Analyses of Calibration Standards)

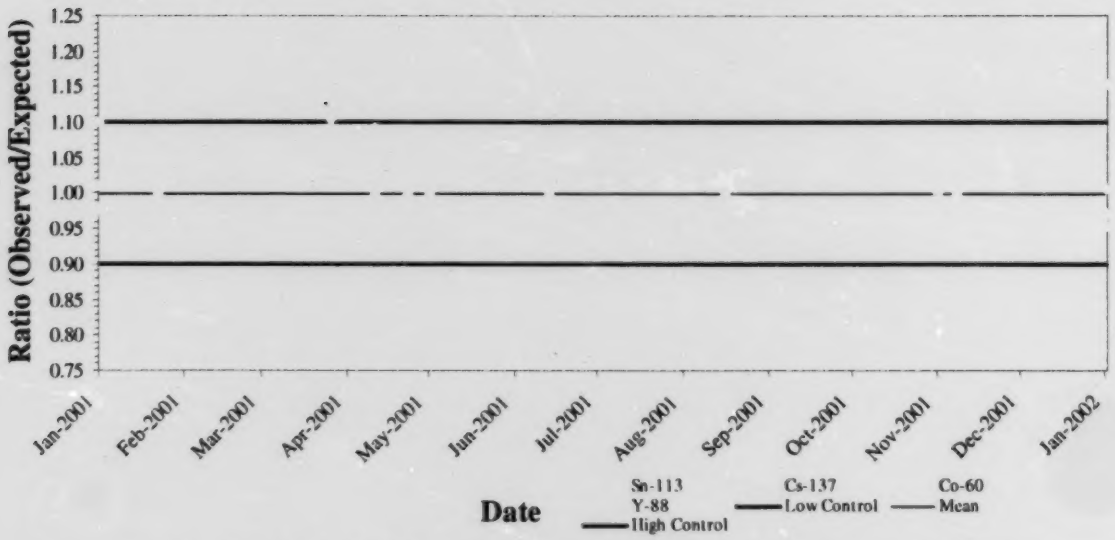

Figure 7.46: Sn-113, Cs-137, Co-60 and Y-88 QA Performance (Internal – Repeated Analyses of Calibration Standards)

7.04 Program Audit

The OERMP is audited every three years. The Independent Assessment Group at PLGS is the principal auditor, although other groups from within NB Power, the CNSC, or other utilities may be used.

In 2001, the Radiation and Environmental Protection Division (REPD) and Power Reactor Operation Division (PROD) of the CNSC, conducted its first evaluation of the OERMP (from October 9 to 12, 2001). The following section contains the main part of the report.

7.04.01 CNSC Program Evaluation

Evaluation of the Radiological Environmental Monitoring Program at Point Lepreau Generating Station, October 9-12, 2001

SUMMARY

At the request of the CNSC Project Office at the Point Lepreau Generating Station (PLGS), an evaluation of the radiological environmental monitoring program was undertaken at that site. The facilities associated with the Operational Environmental Radiation Monitoring Program (OERMP), operated by New Brunswick Power, were visited by staff of the Radiation and Environmental Protection Division (REPD) and Power Reactor Operations Division (PROD) form October 9 to 12, 2001.

The Scope of the evaluation included all aspects of the environmental monitoring program, including organization and administration, program design, field operations, laboratory operations, and data analysis and reporting. The evaluation included interviews with eight key personnel, review of documentation, observations at the Environmental/Dosimetry Laboratory, Fredericton and observations in the vicinity of the Point Lepreau Generating Station. This report acknowledges strength in the Point Lepreau REMP and also presents the weaknesses that were observed during the evaluation.

The evaluation team concludes that the Point Lepreau REMP is meeting most of the objectives of the current New Brunswick Power's PLGS Operational Environmental Radiation Monitoring Program submitted to the CNSC in 2001. However, there are certain aspects of the managed process which have yet to be put into place to ensure that the program continues to perform satisfactorily. To this end, two recommendations and three action notices have been issued in the report.

1. INTRODUCTION

At the request of the Canadian Nuclear Safety Commission (CNSC) Project Office at the Point Lepreau Generating Station, an evaluation of the radiological environmental monitoring program was undertaken at that site. The facilities associated with the Operational Environmental Radiation Monitoring Program (OERMP), operated by New Brunswick Power, were visited by staff of the Radiation and Environmental Protection Division (REPD) and Power Reactor Operation Division (PROD) from October 9 to 12, 2001. This was the first evaluation of the PLGS REMP conducted by the CNSC.

2. PURPOSE AND SCOPE

The purpose of this evaluation was to assess the performance of New Brunswick Power's radiological environmental monitoring program at Point Lepreau Generating Station. This was done in accordance with the authority provided by Sections 30 and 32 of the Nuclear Safety and Control Act. Reference 1 and 2 are NB Power's licensing-reference documents which contain the Operational Environmental Radiation Monitoring Program (OERMP) and the DRL methodology and estimates respectively.

The scope of the evaluation included all aspects of the environmental monitoring program, including:

a) Organization and Administration
b) Program Design
c) Field Operations
d) Laboratory Operations
e) Data Analysis and Reporting

3. EVALUATION PROCESS

3.1 Methodology

The team followed a specific process during the evaluation, using a combination of document review, laboratory and field observations and interviews of selected personnel to elicit significant facts (termed "Basis for Finding"). These facts all pertain to the PLGS OERMP. Findings (or "Judgements") were made by assessing the factual "Basis for Findings" information against a set of pre-determined performance objectives and criteria. The performance objectives and criteria were primarily based on the New Brunswick Power Licensing Reference documents (References 1, 2) with a few additional criteria developed by REPD staff (see Appendix IV). Once the interview process was completed, the relevant

documents reviewed and laboratory and field observations made, the team summarized its Findings (or "Judgements") based on the assembled facts. Contentious or otherwise significant issues raised in the evaluation process were verified prior to inclusion in the report. Staff being interviewed were advised that this approach would be taken. They were also assured that the source of any information would be kept confidential.

A final and essential step in the process consisted of drafting a list of items to be communicated to management at PLGS which, if implemented, would help ensure that the environmental monitoring program would operate at an acceptable level.

3.2 Personnel and Interviews

All the staff at the Environmental/Dosimetry Laboratory Fredericton, and four staff members at the PLGS were interviewed during the course of the evaluation. A list of personnel interviewed is attached as Appendix I. A final meeting was held with PLGS management and staff at Fredericton laboratory to present preliminary findings on October 12, 2001.

3.3 Review of Documents

The documents which were reviewed prior to, during, or subsequent to the site visit are listed in Appendix II.

3.4 Laboratory and Field Observations

Observations were conducted of activities related to environmental monitoring operations, analytical procedures and data reporting during the evaluation. These observations were intended to support the information gathered during the interview process and the observed actual procedures being carried out in the laboratory and in the field.

3.5 Team Members

Members of the evaluation team were:

J. Presley	*REPD (Team Leader)*
J. Kurias	*REPD*
J. Meade	*PROD*
R. Avadhanula	*REPD*

4. FINDINGS

The Findings of the evaluation are listed below. These Findings are the judgements of the evaluation team as to whether a specific aspect of the radiological environmental monitoring program was found to be acceptable or less than adequate.

Appendix IV contains the Objectives and Performance Criteria as well as the "Basis for Findings" or Facts which were used to formulate the Findings with respect to a particular aspect of the environmental monitoring program.

4.1 Organization and Administration

Strengths

1. *There have been examples of staff introducing improvements in the OERMP such as :*

   -Preventative maintenance of air sampling pumps
   -Use of GPS for marking site positions
   -Heating system for CO_2 air samplers

2. *There is very good communication between Fredericton staff and PLGS staff using meetings, telephone and email.*

3. *There is a comprehensive QA/QC program which includes:*

   -Operational instrument checks by laboratory personnel
   -Oversight of QA/QC performance by the Health Physicist
   -Periodic independent assessments by Independent Assessment Group
   -Formal annual review of the program
   -Participation in a number of laboratory intercomparison programs.

Weaknesses

1. *There is no documented training program for the personnel at the Environmental Laboratory.*

2. *The Operational Radiological Environmental Monitoring Program (OERMP) has not been incorporated into the overall quality assurance program of PLGS.*

3. *Not all incidents and problems are being recorded in the PLGS "PICA" system that has been set up for tracking problems and incidents.*

4.2 Environmental Monitoring Program Design

Strengths

1. *The EM program has been designed so that it adequately measures the radioactivity levels in the environment to assess the radiological impact on public health attributable to the operation of Point Lepreau Generating Station.*

4.3 Environmental Monitoring Laboratory and Field Operation

Strengths

1. *There is a complete set of procedures for laboratory analysis and field sampling.*

2. *Comprehensive records are maintained in the Fredericton laboratory of results dating back to the early 1980s.*

3. *Appropriate techniques and properly calibrated laboratory instrumentation are used for all analyses.*

Weakness

1. *Although the personnel in the laboratory were found to be well experienced and competent there are no periodic checks by the supervisor to ensure that personnel are following documented procedures in the laboratory as well as in the field.*

4.4 Environmental Monitoring Data Analysis and Reporting

Strengths

1. *Computer databases are used to trend and record all data from the EM program.*

2. *The 2000 Annual Report was comprehensive containing all of the information mentioned in the performance criteria i.e.:*

    a) *All deviations from the sampling schedule*
    b) *The results of any inter-comparisons and the corrective action*
    c) *The results of the land-use census (includes deviations)*
    d) *The results of the off-site radiological monitoring program*

e) The individual doses that were calculated as doses to the critical group
f) A review of the radiological environmental monitoring quality assurance program
g) Any unusual findings during the calendar year.

Weaknesses

1. There is no documentation of the validation and verification of computer programs used in the laboratory.

5. REMEDIAL ACTIONS

5.1 Description of Remedial Action Categories

Items requiring remedial or corrective action or at least management consideration are categorized according to their level or degree of deviation from expected conditions or performance. Remedial action items will fall under one of three categories.

- *Directives*
- *Action Notices*
- *Recommendations*

***Directive** – A written instruction that requires the recipient to take action to correct:*
-a noncompliance with governing regulations, licence conditions, codes or standards; or
-a general or sustained failure to adhere to approved documents, programmes or processes.
A Directive must result in action which satisfies CNSC staff.

***Action Notice**- A written notification to the recipient for a noncompliance that is not a direct contravention of governing regulations, standards or codes, but that does or can compromise the integrity of the program safety or security. It is usually issued, therefore, for noncompliance with those policies, procedures and instructions that the recipient has established to meet licensing commitments. An Action Notice must result in action that satisfies CNSC staff.*

***Recommendation** –A written suggestion to effect an improvement based on good industry practice. The recipient is not obliged to accept the recommendation. However, a formal response is encouraged.*

5.2 Directives

There are no directives associated with this evaluation.

5.3 Action Notices

Action Notice 01-A-14-A1

NB Power must prepare a documented training program specifically designed for the personnel at the Environmental/Dosimetry Laboratory.

Reference: Section 4.1

Action Notice 01-A-14-A2

NB Power must incorporate the Operational Radiological Environmental Monitoring Program (OERMP) into the overall Quality Assurance (QA) program of PLGS.

Reference: Section 4.1

Action Notice 01-A-14-A3

NB Power must ensure that the validation and verification of computer programs used in the laboratory are documented and software QA is established.

Reference: Section 4.4

5.4 Recommendations

The following recommendations are provided.

Recommendation: 01-A-14-R1

The laboratory supervisor should conduct scheduled checks to ensure that personnel are following documented procedures in the laboratory as well as in the field.

Reference: Section 4.3

Recommendation 01-A-14-R2

NB Power should establish procedures for the E/D Laboratory to record all incidents and problems in the Station PICA (Problem Identification and Corrective Action) system so that corrective actions taken could be verified and trends of recurrent problems be properly analysed.

Reference: Section 4.1

7.04.02 Response

The official Findings from the audit were received after the end of 2001, and are being rectified via the PICA process.

7.05 Annual Review

A major review of the Operational Environmental Radiation Monitoring Program (OERMP) takes place in February of each year. The requirement for this review is stated in the Reference Document (Operational Environmental Radiation Monitoring Program[7]) and described in the Procedure Document (Environmental Radiation Monitoring Program Procedures[11]). All members of the lab take part in this formal review, which is approved by the Manager of Health Physics by the end of March. Generally, all aspects of the program are looked at to make sure that the objectives, as stated in the Reference Document, are being met.

The following are the major items from the review:

1) A study of the onsite groundwater in 2000 identified the need for a new series of bore holes. These were drilled in 2001 and sampling began at that time.
2) The Procedures document was issued in 2001.
3) The first dedicated evaluation of the environmental program by the CNSC took place in 2001.

7.05.01 Routine Monitoring Results

The analyses results are examined for consistency and trends (using graphs and tables created for the Annual Report and using the performance indicators described in the Procedures). Any unusual results and problems are also examined.

This aspect of the review is discussed in sections 4 and 5 of this report.

7.05.02 Procedures

The adequacy and accuracy of field and laboratory procedures are evaluated. New or replacement methods are examined and obsolete ones are identified for deletion. Under the new program, procedures are checked every three years as are their execution by staff. Any deviations from these are to be documented in the Annual Report.

Procedures were revised throughout 2000 and were issued early in 2001.

The only deviation from the written procedures was the increase in count time for the gamma QC from 1000 s to 1500 s.

7.05.03 Analytical QA Results

Failures and biases associated with the Analytical QA Program and the Daily QC Checks are addressed. Graphs and tables produced for the Annual Report as well as the QC Failure Log Book are used. Schedules, number of samples and problems are addressed. The degree of satisfaction with external agencies and options for different suppliers of these samples are explored.

This aspect of the review is discussed in Sections 7.01 and 7.02 of this report.

7.05.04 Equipment

The status of laboratory and field equipment, software and facilities are considered.

Laboratory – All equipment is in good shape. Plans for a refresh of BIN components are being made by PLGS. The centrifuge will be replaced. The air conditioning system will be replaced and ducts will be extended to cover all parts of the facility. The fume hood motor will be replaced.

Software – There is a new Station Instruction that follows the CSA Standard. It governs the process for making changes and additions to analytical software.

Field – The condition of the baby barn at G02 continues to deteriorate but will not have to be replaced in 2002. A new generation of "smart" air pumps will be evaluated this year (purchased last year). The signs on the baby barns will be updated with current phone numbers. Groundwater monitoring equipment will be purchased and brought into use.

7.05.05 Personnel

Training during the previous year are reviewed and plans for the coming year are made from the point of view of program requirements and employee development. Human resources available

to accomplish program objectives are evaluated.

Training suffered in 2001 due to resource constraints, which will continue in 2002. However, a training program for each of the three laboratory positions will be developed and implemented.

7.05.06 Safety

Laboratory and field work safety is reviewed.

Restrictions on working alone in the field will be better defined. Some improvements were made in 2001 from the elimination of some hazardous sampling sites.

7.05.07 Emissions

The final gaseous and liquid effluent reports are studied. Their impact on routine monitoring results and their implications to the OERMP are assessed.

There were no unusual emissions for 2001 that warranted any change to the program. Work on a major revision to the DELs will commence in 2002.

7.05.08 Meteorological Data

The impact on routine monitoring results and the implications to the OERMP are assessed. The results of the Meteorological Monitoring QA analysis are discussed.

The temperature bias in the 42 metre tower data was still not resolved. The use of Pasquill stability factors will be reviewed. Meteorological data are now collected from two different places, but changes are required to take advantage of this.

7.05.09 Emergency Measures Organisation Demographic Data

When available, these data are studied for implications to the program.

The survey took place in 2001. The results are not yet available from New Brunswick Emergency Measures Organization (NBEMO) for analysis. They will be incorporated in the major revision to the DELs, which will commence in 2002.

7.05.10 Appropriateness of Media, Locations and Frequency

The choice of media, and location and frequency of sampling are examined in the broader context of the past year. Possible adjustments are examined to reflect changing conditions in the

Lepreau area and future plans and expectations for PLGS from the public and CNSC.

The broader mandate for the CNSC and the implications of the Priority Substance List II (PSL2) were considered. An action plan will be developed when Environment Canada issues the final document. An Ecological Risk Assessment (ERA) is planned for 2002.

ERA, Environmental Assessment for the refurbishment of PLGS, PSL2, Environmental Effects Monitoring, DELs and future Guidance Documents from the CNSC are expected to alter the program in 2002 and 2003.

- The well water and bore hole sampling locations were increased and monitoring wells near the plant were added.
- The commercial sea urchin fishery was explored for possible inclusion in the program, but determined not to meet program requirements.
- There will be an active search for more private gardens.
- A new aquaculture location in Welch Cove was added.
- A new location for intercepting leachate from the old landfill will be identified.
- There are still no known cows or goats within the area of PLGS.
- Digging clams at Dipper Harbour is a problem (too small to meet Federal Department of Fisheries and Oceans harvesting requirements, beds are closed, locals do not clam there any more due to sparseness, fine grained sediments not as common).
- Regular samples will be taken from the onsite stream.
- TLDs are no longer placed at B9, B10, I90-I95, I98 & I99.
- Well water will no longer be collected at N03.
- Soil and gamma surveys are suspended at Hemlock Knoll.

7.05.11 High LLDs

The summary report of dose to the Critical Group at the LLD is studied.

The major radionuclides that exceed the 5 μSv level (annual average) continue to be noble gases (detection is with a TLD which measures 20 μSv dose). However the noble gas spectrometer on the GEM allows for a much smaller LLD calculation. Other exceptions are:

- Ba-140 in soil (9.1 μSv); sediment (8.6 μSv)
- Ce-144 in pond/puddle/surface water (8.7 μSv); rain water (13.2 μSv); well water (12.0 μSv); garden vegetables (8.3 μSv)
- Co-60 in rain water (5.4 μSv); garden vegetables (5.4 μSv)
- Cs-134 in garden vegetables (5.8 μSv); rain water (5.5 μSv)
- Ru-106 in pond/puddle/surface water (10.4 μSv); rain water (17.2 μSv); well water (11.7 μSv); garden vegetables (20.3 μSv); berries (10.6 μSv); clams (6.7 μSv); fish (6.9 μSv)

Effluent analyses show these are not a major component of release and no changes to counting protocols are warranted

7.05.12 Records

The completeness and consistency of data in the environmental records database are verified at the end of each monitoring year. A QA audit is also performed on the paper copies of analysis reports filed in the laboratory office. The changes to the database are documented.

The only change to the database was the deletion of duplicate gamma results resulting from a logging error.

7.05.13 Contamination

Results from routine contamination monitoring as well as equipment background checks are examined.

There were no contamination issues in 2001.

7.05.14 Problem Resolution

The PICA system at PLGS was implemented to identify, track and trend conditions, concerns, and problems and solutions.

The results from the CNSC evaluation of the OERMP were put into this system.

The Health Physics Department will develop its own unique PICA codes to better track trends.

7.05.15 Changes to Reference Document

Major changes since the last review are documented for the annual report.

The OERMP Reference Document was issued in January, 2000. Major changes since then are:

Changes During 2000

- gross alpha/beta counting is never done on seawater or milk samples
- Sr-89,90 analysis is performed on air filters if more than 1% DEL (GEM) is released from PLGS
- Sr-89,90 analysis is performed on seawater if more than 1% DEL (LEM) is released from PLGS
- soil is not sieved or not always heated before counting
- procedures are checked at least every three years as are their execution by staff
- I-131 is not included in any QA samples
- Sr-89,90 and Cs-137 are not included in Duplicate/Replicate filter samples
- Sr-89 is not included in most QA samples
- the major review of the program takes place in February and is approved in March

- I00G (now I11G) is on the north fence (west side)
- I00I (now I11I) is on the north fence (east side)
- gross alpha/beta counting is done routinely on well water samples, but only on other water samples if they contain significant gamma activity
- three DELs were changed to match CNSC limits (Kr-85, I-131 and I-133)

Changes During 2001

- TLDs are no longer placed at (B9, B10, I90-I95, I98 & I99)
- well water is no longer collected at N03
- a new aquaculture salmon site has been added close to PLGS
- soil and gamma surveys were suspended at Hemlock Knoll
- 18 new bore holes and monitoring wells were added

Planned Changes for 2002:

- more external QA samples will replace internal spikes
- a new groundwater sampling procedure will be implemented
- a new digital air sampler will be evaluated
- implementation of recommendations from
    - Ecological Risk Assessment
    - Environmental Assessment
    - Environment Canada's Priority Substance List 2
    - DEL document
    - new CNSC guidance documents

7.05.16 Program Audit

The results of any audits are reviewed.

This aspect of the review is discussed in Sections 7.04 of this report.

7.05.17 Program Improvement

Areas for improvement are identified:

- *from relevant operating experience (internal & external) (EN-418)*
- *during the annual review (EN-414)*
- *during audits*
- *by laboratory staff*
- *by other HP staff*
- *by HP manager*
- *by the self assessment process*

Deficiencies in any of the listed areas are dealt with promptly. The results of the Annual Review are used to improve the program, and are included in the Annual Report.

During 2000, a study of the groundwater movement on the peninsula was commissioned. The objective was to obtain recommendations for locations of additional bore holes that will better characterise groundwater near PLGS. New holes were drilled in 2001 and sampling was initiated.

Correcting of items arising from the CNSC evaluation and issuing the Procedures were major program improvements for 2001.

Appendices

Appendix A: Statistics, Detection Limits, and Dose at Detection Limits

1 Statistics

The following statistical conventions are applied in the analysis of each sample:

- Detection limits are defined following the method described by Lochamy[12]. The lower limit of detection (LLD) at the 99% confidence level is defined as 6.58 S_b, where S_b is the standard deviation of the appropriate radiation background measurement. This LLD corresponds to that amount of activity in a sample that will yield a net count greater than 3.29 S_b, or the so-called critical level (CL), with 99% probability. Thus, the LLD specifies the theoretical capability of the system to detect a given amount of radioactivity, whereas CL is used to determine whether an actual activity measurement should be considered detected. Any net measurement greater than 3.29 S_b is considered detected at the 99% confidence level. This also implies a 1% probability of stating that activity is present when it is not (false positive). If activity is present at the LLD level (6.58 S_b), there is a 1% probability of stating that activity is not present when it is (false negative).

- The CL of 3.29 S_b and LLD of 6.58 S_b apply in those analytical systems where the background levels are either not well defined, or where there is a relationship between the background levels and the detected signal above background, as in Ge gamma spectroscopy. Where the background readings are well defined and are independent of sample readings, as in the TLD data, the CL is 2.33 S_b and the LLD is 4.66 S_b.

- In most of the tables of data (Section 3.0), it is this Critical Level that appears in column 2.

- Unless otherwise indicated, the precision of the measurements reported here is given as ± 1.96 S_a (95% confidence level), where S_a is the standard deviation of the activity measurement.

- The value and standard deviation are reported with two significant figures using modified scientific notation, for example 0.032 is expressed as 3.2E-02.

The lower limits of detection (LLD) of all radionuclides in the various sample media are shown in Tables A.01 to A.11. The Annual Dose is to a member of the Critical Group. The LLDs are based on typical data. Decay of radionuclides is accounted for in the LLD calculations except for H-3 and C-14 (long half-lives). The major assumptions are that the sample is taken at one kilometre from the point of emissions and that the level is maintained for the year. Milk is assumed to be from a cow pastured at 1.5 km, fish and lobster are caught at the Condenser Cooling Water (CCW) outlet and sediment, dulse, seawater and clams are collected at Dipper Harbour.

The CSA recommends, where technically feasible, that all measurements achieve LLDs less than that which would result in a dose of 5 μSv to the Critical Group. Most radionuclides pass this

criterion. The major exceptions are noble gases. Detection of this group is through TLD measurements (20 μSv dose to the Critical Group at the LLD). However, the noble gas spectrometer on the gaseous effluent monitor allows for a much smaller LLD calculation. Other exceptions are Ba-140 in soil and sediment (10 to 12 μSv); Ru-106 in water and clams (7 to 17 μSv); Ce-144 in water (11 μSv); and I-131 in food (8 μSv). Effluent analyses show these are not major components of release. Part of the QA process identifies those LLDs or activities that do not meet this target.

1.01 Air

1.01.01 Airborne Particulates

Typical LLDs are given for a 2400 m^3 sample, counted for 5000 s. The LLDs are decay corrected to the midpoint between the start and end of sampling, except for the gross alpha/beta results which represent the long-lived activity present a few days after sample collection. Gross alpha/beta is for trending only.

1.01.02 Airborne Radioiodines

A typical LLD for I-131 is approximately 9E-05 Bq/m^3 (for a 2400 m^3 sample, counted for 50 000 s), which is decay corrected to the midpoint between the start and end of sampling.

1.01.03 Airborne Tritium

The LLD is approximately 1E-01 Bq/m^3 of air for a typical sample of 10 to 70 m^3 (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

1.01.04 Airborne Carbon-14

A typical LLD is approximately 4E-02 Bq/m^3 of air for a 30 m^3 sample (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

1.01.05 TLD

The LLD is about 20 μSv. For typical quarterly measurements in the region of 150-200 μSv, measurements can be made to ± 10% at the 95% confidence level.

Table A.01 Annual Dose at the LLD for Air

Nuclide	*LLD (Bq/m^3)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/m^3)*
H-3	9.6E-02	4.8E-02	9.9E+00
C-14	4.0E-02	1.9E+00	1.0E-01
Cr-51	5.8E-04	3.2E-03	9.2E-01
Mn-54	7.8E-05	9.2E-02	4.3E-03
Fe-59	1.7E-04	6.1E-02	1.4E-02
Co-58	8.0E-05	3.5E-02	1.2E-02
Co-60	8.2E-05	1.7E+00	2.4E-04
Zn-65	1.9E-04	3.3E-01	2.9E-03
Kr-85	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-85m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-87	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-88	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Zr-95	1.3E-04	1.1E-01	6.2E-03
Nb-95	9.4E-05	9.9E-02	4.7E-03
Ru-103	7.4E-05	8.1E-03	4.5E-02
Ru-106	6.0E-04	1.0E+00	2.9E-03
Ag-110m	6.2E-05	2.2E-01	1.4E-03
I-131	8.4E-05	1.6E-01	2.5E-03
Xe-131m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-138	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Cs-134	6.4E-05	4.3E-01	7.4E-04
Cs-137	6.6E-05	1.6E+00	2.0E-04
Ba-140	4.8E-04	8.9E-02	2.7E-02
La-140	2.0E-04	2.5E-03	4.1E-01
Ce-141	7.6E-05	4.8E-03	7.9E-02
Ce-144	2.2E-04	2.7E-01	4.0E-03
Noble Gases	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Gross Alpha	6.6E-06		
Gross Beta	1.7E-05		

1.02 Milk

Typical LLDs for the nuclides of interest in milk (a 3.6 L sample counted for 50 000 s for gamma; 6 mL sample counted for 100 min for tritium) are listed in Table A.02 for the time of sample collection.

Table A.02 Annual Dose at the LLD for Milk

Nuclide	*LLD (Bq/L)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/L)*
H-3	2.4E+01	3.1E-01	3.9E+02
Cr-51	6.4E-01	1.0E-02	3.1E+02
Mn-54	9.2E-02	1.9E-02	2.5E+01
Fe-59	2.2E-01	2.2E-01	5.1E+00
Co-58	9.0E-02	7.5E-02	6.0E+00
Co-60	1.1E-01	9.0E-01	6.1E-01
Zn-65	2.4E-01	5.3E-01	2.3E+00
Zr-95	1.6E-01	4.3E-02	1.8E+01
Nb-95	9.2E-02	1.2E-01	3.8E+00
Ru-103	8.4E-02	1.9E-02	2.2E+01
Ru-106	7.8E-01	2.7E+00	1.4E+00
Ag-110m	8.2E-02	5.5E-02	7.4E+00
I-131	9.4E-02	1.8E+00	2.6E-01
Cs-134	7.8E-02	3.1E-01	1.3E+00
Cs-137	9.8E-02	3.1E-01	1.6E+00
Ba-140	3.4E-01	2.1E-01	8.1E+00
La-140	1.1E-01	8.9E-02	6.1E+00
Ce-141	1.2E-01	3.0E-02	2.1E+01
Ce-144	5.0E-01	9.5E-01	2.6E+00

1.03 Water

The LLDs in Table A.03 apply to the time of sample collection for a 3.6 L sample counted for 5000 s for gamma and a 6 mL sampled counted for 100 min for tritium. Alpha/beta results (a 200 mL sample counted for 100 min) represent the long-lived activity present several days after sample collection.

The LLDs are based on typical data for rainwater (the only water sample that has significant decay before analysis). Since decay of radionuclides is accounted for in the LLD calculations, Well Water and other water sample types will have lower LLDs than these. The major assumptions are that the sample is taken at one kilometre from the point of emissions, that the level is maintained for the year and the sample type is the major source of drinking water. Obviously this is not the case but it gives a simple "worst case" that is easy to monitor and calculate.

Table A.03 Annual Dose at the LLD for Water

Nuclide	*LLD (Bq/L)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/L)*
H-3	2.4E+01	3.4E-01	3.6E+02
Cr-51	5.4E+01	7.4E-02	3.7E+03
Mn-54	5.0E-01	1.7E-01	1.4E+01
Fe-59	1.3E+00	9.1E-01	7.1E+00
Co-58	5.6E-01	3.7E-01	7.5E+00
Co-60	4.6E-01	4.5E+00	5.1E-01
Zn-65	1.1E+00	2.3E+00	2.4E+00
Zr-95	9.8E-01	4.0E-01	1.2E+01
Nb-95	6.8E-01	4.0E-01	8.5E+00
Ru-103	6.4E-01	1.8E-01	1.8E+01
Ru-106	4.6E+00	1.7E+01	1.4E+00
Ag-110m	4.6E-01	6.2E-01	3.7E+00
I-131	2.4E+00	3.9E+00	3.1E+00
Cs-134	4.4E-01	4.8E+00	4.6E-01
Cs-137	5.2E-01	3.9E+00	6.6E-01
Ba-140	5.4E+00	2.7E+00	1.0E+01
La-140	2.2E+00	9.1E-01	1.2E+01
Ce-141	8.4E-01	3.4E-01	1.2E+01
Ce-144	2.4E+00	1.1E+01	1.1E+00
Gross Alpha	1.2E-01		
Gross Beta	8.4E-02		

1.04 Food

The LLDs in Table A.04 apply to the time of sample collection. Samples are counted for 5000 s (size varies). The LLDs are based on typical data for garden vegetables. Garden vegetables have significant radioactive decay before analysis (the local residents harvest them and store them in their freezers for varying lengths of time). Since decay of radionuclides is accounted for in the LLD calculations, berries and other food sample types (which experience less radioactive decay) will have lower LLDs than these.

Table A.04 Annual Dose at the LLD for Food

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	3.0E+01	5.9E-02	2.5E+03
Mn-54	3.4E+00	1.3E-01	1.3E+02
Fe-59	7.8E+00	8.4E-01	4.6E+01
Co-58	3.6E+00	3.0E-01	6.0E+01
Co-60	3.8E+00	3.9E+00	4.9E+00
Zn-65	9.0E+00	2.2E+00	2.1E+01
Zr-95	6.2E+00	3.3E-01	9.4E+01
Nb-95	4.0E+00	3.6E-01	5.6E+01
Ru-103	3.8E+00	1.7E-01	1.1E+02
Ru-106	3.0E+01	1.3E+01	1.1E+01
Ag-110m	3.0E+00	4.7E-01	3.2E+01
I-131	1.0E+01	6.9E+00	7.6E+00
Cs-134	3.0E+00	3.6E+00	4.2E+00
Cs-137	3.4E+00	2.9E+00	6.0E+00
Ba-140	2.4E+01	3.5E+00	3.5E+01
La-140	9.4E+00	1.2E+00	4.0E+01
Ce-141	4.2E+00	1.9E-01	1.1E+02
Ce-144	1.4E+01	4.9E+00	1.4E+01

1.05 Soil

The LLDs in Table A.05 apply to the time of sample collection. Samples of approximately 200 g are counted for 5000 s.

Table A.05 Annual Dose at the LLD for Soil

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	4.0E+01	2.5E-01	7.9E+02
Mn-54	5.8E+00	1.2E+00	2.5E+01
Fe-59	1.2E+01	3.1E+00	1.9E+01
Co-58	5.0E+00	1.1E+00	2.2E+01
Co-60	5.8E+00	3.2E+00	9.1E+00
Zn-65	1.3E+01	1.7E+00	3.9E+01
Zr-95	1.0E+01	5.1E+00	9.9E+00
Nb-95	6.0E+00	9.9E-01	3.0E+01
Ru-103	4.8E+00	5.1E-01	4.7E+01
Ru-106	4.6E+01	1.9E+00	1.2E+02
Ag-110m	5.2E+00	2.7E+00	9.7E+00
I-131	6.8E+00	5.2E-01	6.6E+01
Cs-134	5.2E+00	1.5E+00	1.7E+01
Cs-137	5.6E+00	7.1E-01	3.9E+01
Ba-140	2.2E+01	1.1E+01	9.6E+00
La-140	7.2E+00	*	*
Ce-141	6.8E+00	1.2E-01	2.8E+02
Ce-144	2.4E+01	2.9E-01	4.2E+02
TLD	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
*Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

1.06 Seawater

The LLDs in Table A.06 apply to the time of sample collection (for a 3.6 L sample counted for 5000 s for gamma; a 6 mL sampled counted for 100 min for tritium). The dose is small due to the simple facts that the Bay of Fundy is frigid at the best of times (occupancy factor is low) and no one drinks salt water.

Table A.06 Annual Dose at the LLD for Seawater

Nuclide	*LLD (Bq/L)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/L)*
H-3	2.4E+01	9.2E-11	1.3E+12
Cr-51	2.2E+00	2.6E-10	4.3E+10
Mn-54	2.8E-01	7.9E-10	1.8E+09
Fe-59	6.2E-01	2.6E-09	1.2E+09
Co-58	2.8E-01	9.1E-10	1.5E+09
Co-60	3.2E-01	2.4E-09	6.8E+08
Zn-65	6.8E-01	1.3E-09	2.6E+09
Zr-95	5.2E-01	1.2E-09	2.2E+09
Nb-95	3.0E-01	9.3E-10	1.6E+09
Ru-103	2.8E-01	4.4E-10	3.2E+09
Ru-106	2.6E+00	1.6E-09	8.3E+09
Ag-110m	2.6E-01	2.3E-09	5.7E+08
I-131	3.6E-01	2.3E-09	8.0E+08
Cs-134	2.6E-01	1.3E-09	1.0E+09
Cs-137	3.0E-01	5.2E-10	2.9E+09
Ba-140	1.2E+00	2.6E-08	2.4E+08
La-140	4.6E-01	*	*
Ce-141	4.0E-01	1.1E-10	1.8E+10
Ce-144	1.6E+00	2.7E-10	3.0E+10
* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

1.07 Clams

Typical LLDs are given in Table A.07 for the edible portions of clams, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies). The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.07 Annual Dose at the LLD for Clams

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	5.0E+01	2.0E-02	1.3E+04
Mn-54	7.0E+00	6.5E-02	5.4E+02
Fe-59	1.4E+01	3.1E-01	2.3E+02
Co-58	7.2E+00	1.3E-01	2.7E+02
Co-60	6.4E+00	1.8E+00	1.8E+01
Zn-65	1.4E+01	8.8E-01	7.8E+01
Zr-95	1.2E+01	1.5E-01	3.7E+02
Nb-95	6.6E+00	1.4E-01	2.3E+02
Ru-103	6.0E+00	5.5E-02	5.5E+02
Ru-106	5.8E+01	6.5E+00	4.5E+01
Ag-110m	5.8E+00	2.2E-01	1.3E+02
I-131	7.2E+00	9.5E-01	3.8E+01
Cs-134	6.6E+00	1.6E+00	2.1E+01
Cs-137	6.8E+00	1.5E+00	2.2E+01
Ba-140	2.4E+01	7.7E-01	1.6E+02
La-140	9.4E+00	2.2E-01	2.1E+02
Ce-141	7.4E+00	8.0E-02	4.6E+02
Ce-144	3.2E+01	2.6E+00	6.3E+01

1.08 Fish

Typical LLDs are given in Table A.08 for the edible portions of fish, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.08 Annual Dose at the LLD for Fish

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	1.3E+01	1.6E-02	4.0E+03
Mn-54	1.5E+00	5.1E-02	1.5E+02
Fe-59	3.8E+00	2.8E-01	6.8E+01
Co-58	1.5E+00	9.2E-02	8.0E+01
Co-60	1.4E+00	1.3E+00	5.4E+00
Zn-65	3.0E+00	7.0E-01	2.2E+01
Zr-95	2.2E+00	1.1E-01	1.0E+02
Nb-95	1.4E+00	1.1E-01	6.6E+01
Ru-103	1.5E+00	4.9E-02	1.5E+02
Ru-106	1.1E+01	4.4E+00	1.2E+01
Ag-110m	1.2E+00	1.7E-01	3.5E+01
I-131	7.8E+00	1.3E+00	3.1E+01
Cs-134	1.0E+00	1.2E+00	4.5E+00
Cs-137	1.4E+00	1.0E+00	7.1E+00
Ba-140	1.0E+01	7.8E-01	6.4E+01
La-140	4.6E+00	2.4E-01	9.6E+01
Ce-141	1.8E+00	6.0E-02	1.5E+02
Ce-144	5.8E+00	1.6E+00	1.8E+01

1.09 Lobster

Typical LLDs are given in Table A.09 for the edible portions of lobster decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.09 Annual Dose at the LLD for Lobster

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	3.0E+01	1.3E-02	1.2E+04
Mn-54	2.8E+00	2.1E-02	6.7E+02
Fe-59	9.0E+00	1.5E-01	2.9E+02
Co-58	3.2E+00	6.7E-02	2.4E+02
Co-60	3.8E+00	5.4E-01	3.5E+01
Zn-65	7.8E+00	3.4E-01	1.2E+02
Zr-95	5.4E+00	6.8E-02	4.0E+02
Nb-95	4.4E+00	9.0E-02	2.4E+02
Ru-103	4.0E+00	3.1E-02	6.4E+02
Ru-106	3.0E+01	2.4E+00	6.3E+01
Ag-110m	3.4E+00	8.8E-02	1.9E+02
I-131	1.7E+01	3.3E+00	2.6E+01
Cs-134	2.8E+00	6.4E-01	2.2E+01
Cs-137	3.4E+00	4.5E-01	3.8E+01
Ba-140	3.4E+01	1.2E+00	1.4E+02
La-140	1.2E+01	4.2E-01	1.4E+02
Ce-141	4.4E+00	4.3E-02	5.1E+02
Ce-144	1.3E+01	8.7E-01	7.4E+01

1.10 Dulse

Typical LLDs are given in Table A.10 for dulse, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies). The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.10 Annual Dose at the LLD for Dulse

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	2.0E+01	2.4E-03	4.2E+04
Mn-54	3.4E+00	7.4E-03	2.3E+03
Fe-59	8.0E+00	4.4E-02	9.0E+02
Co-58	3.4E+00	1.5E-02	1.1E+03
Co-60	3.4E+00	2.1E-01	7.9E+01
Zn-65	8.2E+00	1.1E-01	3.9E+02
Zr-95	6.6E+00	1.6E-02	2.1E+03
Nb-95	3.6E+00	1.9E-02	9.5E+02
Ru-103	2.8E+00	7.1E-03	2.0E+03
Ru-106	2.6E+01	6.7E-01	2.0E+02
Ag-110m	3.0E+00	2.3E-02	6.4E+02
I-131	5.4E+00	3.0E-01	9.1E+01
Cs-134	2.8E+00	1.9E-01	7.3E+01
Cs-137	3.2E+00	1.3E-01	1.2E+02
Ba-140	1.6E+01	1.6E-01	4.9E+02
La-140	5.4E+00	2.8E-02	9.7E+02
Ce-141	3.4E+00	8.8E-03	1.9E+03
Ce-144	1.4E+01	2.4E-01	2.9E+02

1.11 Sediment

The LLDs in Table A.11 apply to the time of sample collection. Samples weighing approximately 200 g are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.11 Annual Dose at the LLD for Sediment

Nuclide	*LLD (Bq/kg)*	*Dose at LLD (μSv)*	*Activity That Gives 5 μSv (Bq/kg)*
Cr-51	1.7E+01	2.1E-01	4.2E+02
Mn-54	2.8E+00	7.9E-01	1.8E+01
Fe-59	6.2E+00	2.3E+00	1.3E+01
Co-58	2.6E+00	8.4E-01	1.5E+01
Co-60	2.8E+00	2.3E+00	6.1E+00
Zn-65	6.8E+00	1.3E+00	2.7E+01
Zr-95	4.8E+00	3.9E+00	6.1E+00
Nb-95	3.0E+00	7.2E-01	2.1E+01
Ru-103	2.4E+00	3.9E-01	3.1E+01
Ru-106	2.0E+01	1.5E+00	6.6E+01
Ag-110m	2.2E+00	2.1E+00	5.3E+00
I-131	3.4E+00	4.7E-01	3.6E+01
Cs-134	2.0E+00	1.2E+00	8.7E+00
Cs-137	2.8E+00	6.2E-01	2.3E+01
Ba-140	1.2E+01	1.0E+01	5.8E+00
La-140	3.8E+00	*	*
Ce-141	3.0E+00	8.9E-02	1.7E+02
Ce-144	1.1E+01	2.1E-01	2.7E+02
gamma meter	0.01 μSv/h	3.0E+00	1.7E-02
* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

Appendix B: Sample Collection and Analytical Techniques

1 Analytical Techniques

All environmental samples are analysed at the Health Physics Environmental Laboratory in Fredericton. The following pages provide a general summary of the analytical techniques used in the laboratory. Sample collection, preparation and analysis are briefly described, but can be found in detail in the laboratory procedures.

The major analytical techniques and the instruments used in routine environmental analyses are summarised in the Table B.01.

Table B.01 Summary of Analytical Techniques

Analytical Technique	Instrumentation
Gamma Spectroscopy	Canberra 24% efficient* intrinsic, Ge detector in an Applied Physical Technology 10 cm graded lead cave; Canberra S-100 MCA
Liquid Scintillation (tritium and C-14)	Beckman LS 6000TA Liquid Scintillation Counter
Gross Alpha/Beta (Wet Chemical Analysis for Sr-89 and Sr-90)	Tennelec LB-5100 Alpha/Beta Counting System
Gamma Surveys	Eberline Model FH 40G-10 low range gamma survey meter (range 10 nSv/h to 1 Sv/h for 30 keV to 3 MeV photons).
Thermoluminescent Dosimetry	Panasonic UD-710A Automatic TLD Reader and UD-814A1 ($CaSO_4$) dosimeters

*relative to a 3x3 inch sodium iodide detector

In gamma spectroscopy analysis, all significant peaks in the spectrum are identified either by reference to a database library of about 150 radionuclides, or by manual reference to compilations of all known radionuclides. In addition, approximately 20 selected radionuclides are specifically searched for in every sample with the exception of Air Iodine samples in which only I-131 is selected. The selected radionuclides include those that are produced in PLGS, and which would be readily detectable because of their abundance (high fission yield) and high branching ratios for gamma emissions. Naturally occurring gamma emitters, with the exception of Be-7, K-40 and Ac-228, are not included in this report. These excepted radionuclides are sometimes useful as general indicators of the consistency of the analytical techniques.

The peak search and analysis program SAMPO is used to process spectra. The library of radionuclides uses data of the Oak Ridge Laboratory. There are three categories of radionuclides evaluated:

1) selected nuclides of key fission and activation products
2) all other identified radionuclides, including natural radionuclides
3) detected energy peaks for which no identification can be readily made.

The three categories cover all possible eventualities in a spectral analysis and ensure that no significant radionuclides or photon energies will be overlooked.

The usefulness of gross alpha/beta analysis lies primarily in screening samples (to determine whether more detailed analyses should be performed) and showing trends. The reported alpha and beta values are assessed with respect to Am-241 and Sr-Y-90 calibration sources, respectively.

Wet chemical analysis for Sr-89,90 on Gaseous Effluent Monitoring (GEM) and Liquid Effluent Monitoring (LEM) samples follow the American Society for Testing and Materials procedure (using column chromatography).

Liquid samples, other than milk, are acidified upon receipt to keep radionuclides from plating out on the container walls. Perishable samples are refrigerated or frozen.

2 Sample Collection and Analysis

2.01 Airborne Particulates

Airborne particulates are collected on a 47 mm diameter Gelman Type A glass fibre filter, through which air is drawn at about 60 L/min (approximately 2400 m^3 for a 28 day continuous sample). The volume of air sampled is measured with an in-line integrating dry gas meter. Every month the filters are replaced and the used ones are returned to the laboratory for analysis. Sampling is therefore continuous throughout the year, the only interruption (other than power failure or pump breakdown) being the few minutes for a filter change.

Air particulate filters are analysed by gamma spectroscopy as soon as possible after collection to minimise loss of information through radioactive decay (ensure detection of any short lived gamma emitters that may be present, and to minimise any decay corrections). Samples are counted for 5000 s on the Ge detector.

Approximately three days after the end of the sample collection interval, each filter is counted for 100 minutes for the simultaneous determination of gross alpha and gross beta activities. Counting is delayed to allow for the decay of the short-lived radon progeny that would otherwise complicate the analysis.

If significant alpha/beta levels are detected (twice the normal level), further investigation is initiated (longer gamma counts or radiostrontium determinations).

If significant levels of Sr-89,90 (indicating 1% of Weekly DEL) are detected in the chemical analysis of Gaseous Effluent Monitor (GEM) filters, then the air monitoring station particulate filters are also to be analysed for these radionuclides.

2.02 Airborne Radioiodines

Airborne radioiodines are collected in an activated charcoal cartridge placed downstream of the particulate filter. The cartridges are Nuclear Consulting Services NUSORB® (47 mm diameter and 48 mm length), containing 5% TEDA by weight. For a 28 day continuous sample approximately 2400 m^3 of air is sampled at a flow rate of about 60 L/min. The volume of air sampled is measured with an in-line integrating dry gas meter.

Iodine-131 is the major nuclide of interest on the charcoal cartridges. The cartridges are counted in groups of four for 50 000 s on the gamma spectrometer. Counts are performed as soon as possible after collection because of the relatively short-half life of I-131 (8 days). If radioiodines are detected, then the cartridges are re-analysed individually. Other fission product radioiodines, with much shorter half-lives (minutes to hours), decay before they reach the sample location or during the time the sample is being collected. If a significant release of radioiodines were noted from the station in this interval, the samples would be changed and analysed earlier to minimise errors from decay corrections.

2.03 Airborne Tritium

A fraction of the flow in the air monitoring sample station is diverted through a molecular sieve container (Linde type 13X sieve material), to extract water vapour from the sampled air. Sample volume is measured with an in-line integrating dry gas meter.

Sampling is continuous at each location throughout the year, but is interrupted for a few minutes every month to exchange sieve containers. Since the amount of water absorbed by the molecular sieve from a given volume of air depends upon absolute humidity, flow rates are adjusted seasonally (using a Dwyer flow meter) to avoid saturation of the sieve material and to ensure adequate sample collection.

For tritium analysis by liquid scintillation counting, 6 mL of water taken from the molecular sieve condensate is counted for 100 minutes.

2.04 Airborne Carbon-14

An aquarium pump bubbles air through 2N NaOH (1 L), into which carbon dioxide from the air is absorbed. Any C-14 as CO_2 is also absorbed.

Carbon dioxide, in the form of sodium carbonate, is regenerated by acidification and analysed for the determination of C-14 activity. The carbon dioxide is passed through a silica gel trap to remove moisture and tritium and then absorbed into the chemical Carbo-sorb® E until saturation is reached. After the addition of the scintillation cocktail Permafluor® E^+, the sample is analysed for 100 minutes by liquid scintillation counting.

2.05 Environmental Gamma Radiation (TLD)

The environmental thermoluminescent dosimeter is composed of one element of natural lithium borate with no extra filtration, and three elements of calcium sulphate with lead filtration of about 700 mg/cm^2. The badge is sealed in plastic, placed in a screw cap plastic container and suspended about 1 m above the ground for a period of three months. This will measure the ambient gamma dose, whether it is from activity in the air, from the ground or cosmic in origin.

Readout is by the Panasonic UD-710A Automatic Reader. For typical quarterly measurements in the region of 150-200 μSv, measurements can be made to ±10% at the 95% confidence level.

2.06 Soil

Soil samples are collected in undisturbed locations away from nearby buildings or trees. Level areas with some vegetation are preferred. A representative sample (approximately 1.6 kg) of the top 25 mm of a 20 cm by 20 cm area of soil is placed in a disposable polyethylene container.

The soil is dried on a disposable aluminum tray (at 80 °C) and sifted through a 0.5 mm sieve in the laboratory (a 1 mm sieve is used for coarse soils). Approximately 0.25 kg of dry soil is counted by gamma spectroscopy for 5000 s.

2.07 Food

Garden produce and berries, which are either collected or purchased, require no special preparation. The edible portion is put in a calibrated container and weighed (size varies). This is counted by gamma spectroscopy for 5000 s.

2.08 Milk

A 4L sample is purchased and placed in a clean polyethylene container.

For gamma spectroscopy, a 3.6 L aliquot is measured into a marinelli beaker. The remainder is distilled, and a 6 mL aliquot is analysed by liquid scintillation counting for 100 minutes. Count times are 50 000 s for gamma spectroscopy and 100 min for tritium analysis.

2.09 Water

A 4L sample of well water, pond water, lake water or surface runoff is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. After gamma analysis, well water samples (125-500 mL, depending upon the dissolved solids content) are evaporated to dryness on stainless steel planchets for gross alpha/beta analysis. For tritium analysis by liquid scintillation techniques, a 6 mL aliquot is analysed by liquid scintillation counting. For gamma spectroscopy, the sample is counted for 5000 s. For tritium and gross alpha/beta analyses, samples are counted for 100 min. A level twice the normal level for alpha/beta will initiate further investigation (longer gamma counts and/or Sr-89/90 analyses).

Measurements of gross alpha and beta are made about two weeks after sample collection. This delay avoids analytical interference from radon progeny whose activity is tied to that of the parent, which decays with a half-life of about 3.8 days. Natural radon and radon progeny occur in well waters everywhere and are known to reach high concentrations in many New Brunswick locations.

2.10 Vegetation

The only vegetation types routinely collected and analysed are tree lichen (Spanish moss) and various ground mosses such as Cladonia and Lycopodium. They concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to man.

About 25 g or more of each of the samples is collected and air-dried before analysis. No special preparation is required. The sample is placed in a calibrated container and weighed. This is counted by gamma spectroscopy for 5000 s.

2.11 Precipitation

Rain is collected continuously during the milder months.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

2.12 Sediment and Beach Surveys

Beach sediment samples are collected near the low tide mark, with preference being given to the top 10 mm of the fine sediment characteristic of tidal mud flats. A disposable polyethylene container is used to collect about 1 kg of sample. In addition, direct gamma radiation dose rate measurements are made at each sediment site using an Eberline Model FH 40G-10 low range gamma survey meter (range 10 nSv/h to 1 Sv/h for 30 keV to 3 MeV photons). The meter is held for one minute at a point one metre from the inter-tidal surface. After the sediment sample has been collected, this is repeated.

The sample is transferred to a disposable aluminum tray for drying at 80 °C. Dried, caked samples are broken into their original free granular form with a porcelain mortar and pestle, and sieved through a 0.5 mm mesh to collect the fines for analysis (a 1 mm sieve is used for coarse sediments). Approximately 0.25 kg of dried sediment is counted by gamma spectroscopy for 5000 s.

2.13 Seafood

The inshore fishery throughout the Maritimes has declined since the OERMP was started in 1982. Some of it has been closed to any kind of harvesting. However, species of local seafood are collected when available from local fishermen. Sampling focuses on fish, lobsters and clams. Some of the areas where clam harvesting is prohibited are sampled with the permission of the Department of Fisheries and Ocean. Other seafood species are more mobile and can sometimes be found throughout the area: crab, periwinkles, aquaculture salmon, scallops, herring, mackerel, dogfish, cod, haddock, sea urchin, mussels, and flounder. The severe restrictions placed on the inshore fishery as well as the depletion of stocks make many of these samples unavailable most of the time (sometimes spanning years). However, whenever they are available an effort is made to collect as many samples as possible. Approximately 0.5 kg of fresh seafood is collected per sample.

Approximately 0.25 kg of each sample is prepared for gamma spectroscopy. Lobsters are cooked first, and the edible meat is removed for analysis. Clams, periwinkles, and crab are analysed whole, with a yield factor applied to account for the mass of the inedible shell. The edible portion of fish is analysed. Samples are counted for 5000 s.

2.14 Aquatic Plants

Dulse (Rhodymenia palmata), an edible seaweed which is commercially harvested in the area, is collected monthly when available. Other species of seaweed concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to man.

A portion of the seaweed or dulse is put in a calibrated container and weighed (size varies). This is counted by gamma spectroscopy for 5000 s.

2.15 Seawater

A 4L sample is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

If significant levels of Sr-89,90 (indicating 1% of Monthly DEL) are detected in the chemical analysis of the LEM composite, then the seawater is also to be analysed for these radionuclides.

2.16 Miscellaneous Samples

This category encompasses all of those samples collected that do not fall within the other categories. It is a mechanism by which the lab can track and evaluate media for potential inclusion in the program. It gives the program flexibility and freedom and encourages the scientific curiosity of laboratory staff. A few of the media types started out this way. As many as 50 samples per year are analysed, including deer liver, mud puddles, snow, sea urchin and mussels.

2.17 Bore Holes

A 4L sample of water is pumped out of the bore hole into a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

2.18 Parshall Flume

PLGS staff collect a 4L sample of water from the Parshall flume systems.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

2.19 Hemlock Knoll Regional Sanitary Landfill

In December 1999, PLGS began disposing of its non-active waste at the public landfill facility. A monitoring program was established prior to the first shipment. It includes sampling of water from the leachate, bore holes and various holding ponds; sampling of the soil and gamma surveys of the disposal cell surface; and dosimeter placement at key locations.

Although some extra precautions are observed due to the potential biohazard of some of these samples, they are analysed according to established procedures previously described.

Appendix C: Location Codes

A 5m	PLGS Dry Fuel Storage Facility - 5 m NNE from perimeter fence
A 10m	PLGS Dry Fuel Storage Facility - 10 m NNE from perimeter fence
A 15m	PLGS Dry Fuel Storage Facility - 15 m NNE from perimeter fence
A 20m	PLGS Dry Fuel Storage Facility – 20 m NNE from perimeter fence
A 25m	PLGS Dry Fuel Storage Facility - 25 m NNE from perimeter fence
A 50m	PLGS Dry Fuel Storage Facility – 50 m NNE from perimeter fence
A 75m	PLGS Dry Fuel Storage Facility – 75 m NNE from perimeter fence
A 100m	PLGS Dry Fuel Storage Facility – 100 m NNE from perimeter fence
A 118m	PLGS Dry Fuel Storage Facility – 118 m NNE from perimeter fence
A01R	Bocabec – Barry & Michelle Schriver
A02R	Bocabec - field across from A01R
A03R	Bocabec – inter-tidal zone
A04	Bayside – Alexander Muir (Fairmile Farm)
A05R	Letete
A06	Digdeguash
A07	Beaver Harbour
A08	Back Bay
A09	Chamcook
A10R	Grand Manan
A12	St. Andrews

A11	Oak Bay / Waweig
AECL	Atomic Energy of Canada Ltd., Chalk River (QA)
B 5m	PLGS Dry Fuel Storage Facility – 5 m WNW from perimeter fence
B 10m	PLGS Dry Fuel Storage Facility – 10 m WNW from perimeter fence
B 15m	PLGS Dry Fuel Storage Facility – 15 m WNW from perimeter fence
B 20m	PLGS Dry Fuel Storage Facility – 20 m WNW from perimeter fence
B 25m	PLGS Dry Fuel Storage Facility – 25 m WNW from perimeter fence
B 50m	PLGS Dry Fuel Storage Facility – 50 m WNW from perimeter fence
B 75m	PLGS Dry Fuel Storage Facility – 75 m WNW from perimeter fence
B 100m	PLGS Dry Fuel Storage Facility – 100 m WNW from perimeter fence
B 150m	PLGS Dry Fuel Storage Facility – 150 m WNW from perimeter fence
B 200m	PLGS Dry Fuel Storage Facility – 200 m WNW from perimeter fence
B01	New River Beach - inter-tidal zone
B02	Pocologan
B03	New River Beach - park
B04	New River Harbour to Pocologan Harbour
B10	Pennfield
BAXR	Baxter's Dairy
BB	PLGS – Boiler Blow-down
BD	Belledune GS

C01	Lepreau Harbour – inter-tidal zone
C03	Lepreau
CCW	PLGS – Condenser Cooling Water Duct
CH	Chatham GS
COG	CANDU Owners Group
D01	Little Lepreau Basin - inter-tidal zone (remnants of clam shack)
D02	Little Lepreau
D03	Little Lepreau – Zelda McPherson
D04	Little Lepreau Basin – inter-tidal zone (remnants of boat wreck)
DH	Dalhousie GS
DOE	US Department of Energy (QA)
DUMP	PLGS – onsite landfill
DWC	PLGS – drinking water fountains
E01	Maces Bay – Floyd Small
E02	Maces Bay – Fundy Senior Citizens Centre
E03	Maces Bay – inter-tidal zone
E04	Maces Bay Cemetery
E05	Fundy Shores Elementary School – outside (Thompson/Trynor's Field)
E06	Fundy Shores Elementary School – inside
E07	Near intersection of route 790, Maces Bay Rd. and County Line Rd.
E11	28 Ridge Rd., Camick

E12	22 Ridge Rd. (WW #07)
E13	16 Ridge Rd., Brown
E14	10 Ridge Rd., Crawford
E15	4 Ridge Rd., Belding
EDU	Edutech Enterprises
EPA	US Environmental Protection Agency (QA)
F01	Welch Cove – Dave Wright
F02	Welch Cove – inter-tidal zone
F03	190 Welch Cove Rd., LJP Comeau
F04	195 Welch Cove Rd., JM Mawhinney
F05	181 Ridge Rd., Davidson
F06	132 Ridge Rd., Mawhinney
F07	68 Ridge Rd., Cook
G01	Indian Cove – inter-tidal zone
G02	Point Lepreau – lighthouse
G03	offshore – within 2 km of Point Lepreau lighthouse
G04	PLGS - inter-tidal zone 1 km south of CCW out-fall
GEM	PLGS – Gaseous Effluent Monitor
GL	Grand Lake GS
H01	Duck Cove – duck pond
H02	offshore – close to PLGS condenser cooling water out-fall

H03	Duck Cove - inter-tidal zone
H04	PLGS – across the road from old site of Information Centre building
H05	PLGS - start of nature trail near old site of Information Centre trailers
HS	Hanson Stream Reservoir
I00	PLGS SRWMF Phase 1– general site area
I01	PLGS SRWMF Phase 1
I02	PLGS SRWMF Phase 2
I03	PLGS SRWMF Phase 2 – general site area
I10A	PLGS SRWMF Phase 1 Bore Hole A (BHA)
I10B	PLGS SRWMF Phase 1 Bore Hole B (BHB)
I10C	PLGS SRWMF Phase 1 Bore Hole C (BHC)
I10D	PLGS SRWMF Phase 1 at I01 Barn (Shallow Bore Hole)
I10E	PLGS SRWMF Phase 1 at I01 Barn (Deep Bore Hole)
I10F	PLGS SRWMF Phase 1 Bore Hole southeast from C structure
I10G	FUTURE BORE HOLE
I10H	FUTURE BORE HOLE
I10I	FUTURE BORE HOLE
I11A	PLGS SRWMF Phase 1 - south fence (east side)
I11B	PLGS SRWMF Phase 1 - south fence (centre)
I11C	PLGS SRWMF Phase 1 - south fence (west side)
I11D	PLGS SRWMF Phase 1 - west fence (south side)
I11E	PLGS SRWMF Phase 1- west fence (centre)
I11F	PLGS SRWMF Phase 1 - west fence (north side)
I11G	PLGS SRWMF Phase 1 - north fence (west side)
I11H	PLGS SRWMF Phase 1 - north fence (centre)
I11I	PLGS SRWMF Phase 1 - north fence (east side)
I11J	PLGS SRWMF Phase 1 - east fence (north side)
I11K	PLGS SRWMF Phase 1 - east fence (centre)
I11L	PLGS SRWMF Phase 1 - east fence (south side)
I1A1	PLGS SRWMF Phase 1 – Cell 1A1
I1A2	PLGS SRWMF Phase 1 – Cell 1A2
I20A	PLGS SRWMF PHASE 2 – well #4 (shallow) BH4
I20B	PLGS SRWMF PHASE 2 – well #4 (deep) BH4
I20C	PLGS SRWMF PHASE 2 - well #7 (shallow) BH7
I20D	PLGS SRWMF PHASE 2 - well #7 (deep) BH7
I20E	PLGS SRWMF PHASE 2 – well #6 (shallow) BH6
I20F	PLGS SRWMF PHASE 2 - well #6 (deep) BH6
I20G	PLGS SRWMF PHASE 2 – well #5 (shallow) BH5
I20H	PLGS SRWMF PHASE 2 – well #5 (deep) BH5
I20I	PLGS SRWMF PHASE 2 – well #2 (shallow) BH2
I20J	PLGS SRWMF PHASE 2 - well #2 (deep) BH2
I20K	PLGS SRWMF PHASE 2 - well #3 (shallow) BH3

I20L	PLGS SRWMF PHASE 2 – well #3 (deep) BH3
I20M	PLGS SRWMF PHASE 2 – well #1 (shallow) BH1
I20N	PLGS SRWMF PHASE 2 – well #1 (deep) BH1
I20P	PLGS SRWMF PHASE 2 – north from bore hole 1
I20Q	PLGS SRWMF PHASE 2 – south from bore hole 2 (shallow)
I20S	PLGS SRWMF PHASE 2 – south from bore hole 2 (deep)
I20T	PLGS SRWMF PHASE 2 – north from bore hole 2
I20U	PLGS SRWMF PHASE 2 – well #8 shallow (BH8)
I20V	PLGS SRWMF PHASE 2 – well #8 deep (BH8)
I21A	PLGS SRWMF PHASE 2 – Periphery – south fence (east side)
I21B	PLGS SRWMF PHASE 2 - Periphery – south fence (centre)
I21C	PLGS SRWMF PHASE 2 - Periphery – south fence (west side)
I21D	PLGS SRWMF PHASE 2 - Periphery – west fence (south side)
I21E	PLGS SRWMF PHASE 2- Periphery - west fence (centre)
I21F	PLGS SRWMF PHASE 2 - Periphery - west fence (north side)
I21G	PLGS SRWMF PHASE 2 – Periphery – north fence (west side)
I21H	PLGS SRWMF PHASE 2 - Periphery – north fence (centre)
I21I	PLGS SRWMF PHASE 2 - Periphery – north fence (east side)
I21J	PLGS SRWMF PHASE 2 – Periphery – east fence (north side)
I21K	PLGS SRWMF PHASE 2 – Periphery – east fence (centre)
I21L	PLGS SRWMF PHASE 2 - Periphery – east fence (east side)

I70	PLGS – woods between plant & SRWMF
I71	PLGS - Near Plant Monitoring Well MW01-10, northeast from RB
I75	PLGS – north 73° east, 85 m from the stack (on pole)
I86	PLGS – 2nd pole from SRWMF driveway heading toward outer gate
I87	PLGS –3rd pole from SRWMF driveway heading toward outer gate
I88	PLGS – 4th pole from SRWMF driveway heading toward outer gate
I89	PLGS -5th pole from SRWMF driveway heading toward outer gate
I90	At distribution line on west side of Point Lepreau Rd.
I91	100 m north of distribution line on west side of Point Lepreau Rd.
I92	200 m north of distribution line on west side of Point Lepreau Rd.
I93	300 m north of distribution line on west side of Point Lepreau Rd.
I94	400 m north of distribution line on west side of Point Lepreau Rd.
I95	500 m north of distribution line on west side of Point Lepreau Rd.
I96	on the old Dupont warning sign at the end of the old "dynamite road"
I97	on the west side of the clearing at the end of the old "dynamite road"
I98	PLGS – north of SRWMF PHASE 2 (200 m north of transmission line)
I99	PLGS – north of SRWMF PHASE 2 – (100 m north of transmission line)
IAEA	International Atomic Energy Agency (QA)
J00	PLGS – south, 180 m from the stack (on fence)
J01	PLGS - Near Plant Monitoring Well MW01-1, near surge shaft
J02A	PLGS - Near Plant Monitoring Well MW01-2 (shallow), SSE from RB

J02B	PLGS - Near Plant Monitoring Well MW01-2 (deep), SSE from RB
J20	PLGS – south 19° east, 115 m from the stack (on fence)
J35	PLGS – south 34° east, 135 m from the stack (on sign)
J70	PLGS – south 69° east, 70 m from the stack (on pole)
K00	PLGS - Near Plant Monitoring Well MW01-3 south from RB
K01	PLGS – 95 m west of south gate leading to the lighthouse
K02	PLGS Cooling Water Pump-house – east fence near surge shaft
K03	PLGS - Near Plant Monitoring Well MW01-4 SSW from RB
K03C	PLGS sewage lagoon (chlorine contact tank)
K03E	PLGS inactive drainage (east lagoon)
K03W	PLGS inactive drainage (west lagoon)
K04	PLGS - Near Plant Monitoring Well MW01-5, WSW from RB
KDRP	KD Radpro
L01	PLGS – site of old cement plant
L02	PLGS – switchyard
L03	PLGS – outer security building (main gate)
L04	PLGS – construction stores
L05	PLGS - Near Plant Monitoring Well MW01-6, WNW from RB
L06	PLGS - Near Plant Monitoring Well MW01-7, paved staff parking lot
L07	PLGS - Near Plant Monitoring Well MW01-8, construction parking lot
L08	PLGS - Near Plant Monitoring Well MW01-9, N beyond fire training area

LAB	Fredericton – Health Physics Laboratory
LEM	PLGS – Liquid Effluent Monitor
M02	PLGS – Administration Building (2nd floor)
MISC	Miscellaneous locations
MQ	Mactaquac GS
N01	Dipper Harbour – Greg Thompson
N02	Dipper Harbour – Dewey Janes
N03	Dipper Harbour – Ethel Thompson
N04	Dipper Harbour – inter-tidal zone
N05	Dipper Harbour – beach behind restaurant
N06	Dipper Harbour – offshore
NTS	Nuclear Technology Services Inc. (QA)
P01	Chance Harbour
P02	Little Dipper Harbour
P03	Liberty Hill
P04	Round Meadow Farm
P05	Chance Harbour – 2 km offshore
PLGS	PLGS – general
Q01R	Lorneville
RPB	Radiation Protection Bureau, Health Canada (QA)
RPC	Research and Productivity Council

S00	Saint John and surrounding area
S10	Hammond River (Mike Steele)
SPL	Spruce Lake reservoir
TAYR	Taymouth
X03R	Fredericton - Chestnut Complex lab
X04R	Fredericton – reference seafood
X05R	Fredericton – reference milk test (B. Gay)

X06R	West of Fredericton (Silverwood)
X10	Fredericton Junction – Atlantic Dairy Institute
X12	York Mills
Y#####	Hemlock Knoll Regional Sanitary Landfill

Appendix D: Abbreviations

AECL	Atomic Energy of Canada Limited
CCW	Condenser Cooling Water
CL	Critical Level
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
DEL	Derived Emission Limit
FWHM	Full Width Half Maxima
GEM	Gaseous Effluent Monitor
IAEA	International Atomic Energy Agency
LEM	Liquid Effluent Monitor
LLD	Lower Limit of Detection
LSC	Liquid Scintillation Counter
MSDS	Material Safety Data Sheet
NBEMO	New Brunswick Emergency Measures Organization
NIST	National Institute of Standards and Technology
NRC	National Research Council
NTS	Nuclear Technology Services
OERMP	Operational Environmental Radiation Monitoring Program
OPEX	Operating Experience
PLGS	Point Lepreau Generating Station
PROD	Power Reactor Operation Division
PSL2	Priority Substance List II
QA	Quality Assurance
QC	Quality Control
REPD	Radiation and Environmental Protection Division
RPB	Radiation Protection Bureau
SRWMF	Solid Radioactive Waste Management Facility
TLD	Thermoluminescent Dosimeter
USDOE	United States Department of Energy

Appendix E: Environmental Reports of Previous Years

PRE-OPERATIONAL (1976 - 1981)

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. October 1, 1976 to June 30, 1979. NBEPC-HP-79-1. J.A. Flanigan and J.J. Paciga. Sept. 1979.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1979 to December 31, 1979. NBEPC-HP-80-1. J.A. Flanigan. Sept. 1980.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1980 to December 31, 1980. NBEPC-HP-81-1. J.K. Sutherland and J.A. Flanigan. July 1981.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1981 to December 31, 1981. NBEPC-HP-82-1. J.K. Sutherland. February 1982.

OPERATIONAL (1982 - 2000)

Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1982 (to 1997) to December 31, 1982 (to 1997). HP-07000-83 (to 98)-1. J.K. Sutherland. March 1983 (to 1998).

Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1998 (to 2000) to December 31, 1998 (to 2000). HP-07000-1999 (to 2001)-1. J.C. McCulley. April 1999 (to 2001).

Appendix F: References

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3. Nason, J., *Liquid and Gaseous Effluent Monitoring Program RD-01364-L20 Rev.3*, Point Lepreau Generating Station Reference Document, 1997.

4. Sutherland, J., *Derived Emission Limits for Radionuclides in Airborne and Liquid Effluents RD-01364-L1*, Point Lepreau Generating Station Reference Document, 1996.

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10. *External Beta/Gamma Dosimetry Program, HP-03541-2-TL Rev. 4*, Point Lepreau Generating Station Procedure Document, 2001.

11. *Environmental Radiation Monitoring Program Procedures, HP-03541-2-EN*, Point Lepreau Generating Station Procedure Document, 2001.

12. NBS Special Publication 456, *Measurements for the Safe Use of Radiation*, US Department of Commerce, 1976.

Appendix G: Distribution List

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